SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXIX OCTOBER, 1939 WHOLE NO. 342

THE CONVENTION IS COMING!

The Friday afternoon section meetings at the last convention were crowded to overflowing. We are happy to announce that, with the housing facilities arranged for the 1939 meeting, each of these sections will have larger quarters. Even so, after reading about the speakers for these meetings, you will realize that again you must be on hand early.

The general and section officers are ready to introduce to you the persons who have kindly agreed to appear on these Friday afternoon section programs.

Dr. Louis M. Heil will speak on the subject "Physics in General Education" to the Physics Section. Dr. Heil is Associate Professor of Education at the University of Chicago. He has recently published papers on "Measuring Student Achievement in the Physical Sciences," "The Use of Visual Materials to Teach Certain Aspects of Critical Thinking," and "Measuring the Listerners' Appreciation to a Series of Radio Programs." He has served as research assistant for the A. A. A. S. Committee on Improvement of Science Instruction for the Purposes of General Education, research associate in the Eight Year Study on the Relationship between College and Secondary Schools, and Research Associate on the Evaluation of School Broadcasts. He is author of the book, *Physical World*.

Dr. E. U. Condon will use as his subject, "Physics as a Career." Dr. Condon is Associate Director of the Westinghouse Research Laboratories at East Pittsburgh, Pennsylvania. He has recently published papers on the "Theory of Optical Rotatory Power" and "Contact Potentials of Semi Conductors." He is a member of the Council of the Division of Physical Sciences of the National Research Council and of the Board of Editors of

the *Journal of Chemical Physics* and the *American Physics Teacher*. Dr. Condon is editor of a series of Physics texts and has written books on the theory of atomic spectra and quantum mechanics.

"Forward Looking Steps in the Teaching of Physics" will be the topic discussed by *Dr. S. R. Powers*, Professor of Natural Sciences, Teachers College, Columbia University. Dr. Powers is author of *The World Around Us*, *This Changing World*, and *Man's Control of his Environment*, three volumes which form a survey of science for junior high schools. He has also published books concerned with Chemistry and tests.

Mr. Philip Tapley of Tilden High School, Chicago, who will speak on "The Selection of Apparatus for High School Physics," is chairman of the committee on Apparatus and Equipment for the club of Physics teachers in Chicago.

The Chemistry Section has been fortunate in securing the services of *Dr. Malcolm Dole*, an Associate Professor at Northwestern University. He is a physical chemist and has worked on pH and its measurement as well as natural occurrence of hydrogen and heavy water. His subject will be "Methods and Importance of pH and Acidity Measurements."

Dr. Fred C. Koch will address the same section on "The Contributions of Chemistry in the Field of Hormones to Health Control." Dr. Koch is Chairman of the Department of Biochemistry at the University of Chicago. He has worked on enzymes, hormones, vitamins and biochemical methods.

Dr. H. H. Sheldon, Managing Trustee of the American Institute of the City of New York, will explain the Science Club program of that institute. Dr. Sheldon is connected with New York University and was at one time Science Editor of the *New York Tribune*. He has worked on absorption of gases by charcoal, conduction of electricity through crystals, voice analysis and photoelectric color measurement.

The chemistry program will also include a panel discussion on the Future of the Specialized Sciences in High Schools including *Dr. J. O. Frank*, Chairman of the Chemistry Department, State Teachers College, Oshkosh, Wisconsin; *Theodore Kelsey*, Cleveland High School, St. Louis, Missouri; *Martin McGill*, Chairman of the Division of Chemical Education, American Chemical Society, of Lorain, Ohio; *Dr. Victor H. Noll*, Acting Head of the Department of Education, Michigan State College, East Lansing, Michigan.

"The Geographer, the Land and the People" will be the topic of *Dr. Helen Strong* before the Geography Section. Dr. Strong is a geographer dealing directly with land use problems, She is in charge of educational relations for the Soil Conservation Service of the United States Department of Agriculture, which involves translation of the scientific research, land use, and flood control work of this Service into educational activities of all levels.

Dr. F. K. Branom, Head of the Department of Social Sciences at Chicago Teachers' College, will explain "Some of the Problems Confronting the Geography Teacher." Dr. Branom is author of the *Use of Maps, Use of Globes, Geography of Illinois* and co-author of several Geography textbooks. He is editor of the *Pictorial Atlas of the World* and other atlases.

Professor Edith Glatfelter will discuss the "Relation between High School and College Geography." She is Professor of Geography at Harris Teachers College, St. Louis, Missouri, a four year training school for the St. Louis elementary schools.

Mathematicians will be glad to hear that *Dr. Maurice S. Hartung* will address the Mathematics Section on "Issues Raised by Recent Reports on the Mathematics Curriculum," Dr. Hartung is Associate Director of the Progressive Education Association and is chairman of Mathematics Committee of the Commission on the Secondary School Curriculum of that organization. He is also a member of the Joint Committee of the Mathematical Association of America and the National Council of Mathematics teachers on the Place of Mathematics in Secondary Education.

Dr. E. R. Hedrick, Vice President and Provost of the University of California at Los Angeles, is scheduled to speak on the general program and also the Mathematics Section program, as also is *Dr. Raleigh Schorling*, Head of the Department of Mathematics in the University High School, University of Michigan.

Speakers for the Biology, General Science and Elementary Science Sections were listed in the June issue of SCHOOL SCIENCE AND MATHEMATICS. More information concerning these speakers will appear in the November issue.

Due to the change in the date of Thanksgiving Day, the convention will be held November 24 and 25 of this year.

MARIE S. WILCOX, *President*

OF CONCERN TO MEMBERS OF THE CENTRAL ASSOCIATION

Your Association promotes its membership largely through the efforts of a small committee having representatives only in the six states most centrally located with regard to the present membership. The budget requires a minimum financial outlay. The Association therefore lacks the expansion which might follow extensive and intensive field work. There are possibly considerable numbers of teachers eligible to membership who have not even heard of the services and values offered for our modest membership fee.

Your Membership Committee urgently desires to enlist the assistance of all members of the Association in informing other teachers concerning the values of our annual convention programs, the quality of the journal, and the general desirability of belonging to this type of outstanding professional organization. We trust that all members agree that our Association offers certain outstanding values and advantages worthy of serious consideration by non-member teachers. Among these, the following may be listed:

1. An annual convention of outstanding merit, always held at a time and place which make it reasonably possible for members to attend.
2. Opportunity at the convention to see and become familiar with the latest developments in textbooks, laboratory equipment, visual aids, and other teaching materials.
3. Committees, sections, and general offices which offer positions of leadership for those desiring responsibility in social and professional contact with prominent teachers.
4. A journal recognized as quite unique in its field, having as its mission the coordination of all the natural sciences, including the most basic of the sciences—mathematics. This aim is highly significant in terms of present trends toward unification of subject matter.
5. Opportunity to contribute through the journal and the convention to the development of our profession.
6. A national reputation as a living, progressive organization interested in cooperating with similar groups for common improvement.

We believe every member may well be proud to present these values to other teachers. If there are those who seem critical, we

should cordially invite their assistance toward improvement. All who desire individual and group improvement will become worthy members.

Printed programs of the next convention, Yearbooks, sample copies of the journal, and other information will be gladly supplied free for use to any member or will be sent directly to any non-member desiring to be more fully informed. Please address requests for such materials to any member of the committee listed below.

For the Membership Committee:

Ray C. Soliday, Chairman
Oak Park-River Forest Twp. H. S.
Oak Park, Illinois

Mahlon H. Buell
Senior High School
Ann Arbor, Michigan

Geraldine Reep Johnson
George Washington High School
Indianapolis, Indiana

Ernestine M. J. Long
Normandy High School
St. Louis, Missouri

Theodore A. Nelson
Decatur High School
Decatur, Illinois

Milton D. Oestreicher
Francis W. Parker School
Chicago, Illinois

George Peterson
North High School
Sheboygan, Wisconsin

Kenneth Vordenberg
Washington Jr. High School
Cincinnati, Ohio

SHORTITE

Discovery of a new mineral, officially named "shortite," has been announced by the Geological Survey, Department of the Interior.

Composed of a double carbonate of sodium and calcium, the new mineral was found and identified by J. J. Fahey, chemist, in the Geological Survey laborabory. It was discovered as disseminated well-formed crystals in sections of core from the John Hay oil and gas well, drilled by Mountain Fuel Supply Company on leased Government land in Sweetwater County, Wyoming, at depths of 1,250 to 1,800 feet below the earth's surface. Shortite was named in honor of Dr. M. N. Short, a former geologist of the Survey who now is Professor of Optical Mineralogy at the University of Arizona.

The new mineral might be adapted to use in glassmaking and ceramics work should it ever be found in sufficient quantities, officials of the Geological Survey said.

Additional samples for further laboratory examination will be collected by Mr. Fahey who has left Washington for the shortite-bearing area. It is expected that sections of core, two inches in diameter, and totaling a few hundred feet length will be transported to Washington.

The new find probably will be one of the few mineral discoveries for the year. So thoroughly has the earth been combed that, during the past two years only about twenty new minerals were discovered in the entire world.

THE CLEVELAND NATURAL SCIENCE CLUB

ELLIS C. PERSING
School of Education, Western Reserve University and West Technical High School, Cleveland, Ohio

A lodge constructed of logs, located in a forested area, and within twenty miles of a large city—this is the Cleveland Natural Science Club—Look About Lodge.

This building has been designed to meet the needs of a group of scientifically minded people. The assembly room has a capacity of two hundred persons. It is 60×24 with two large fireplaces, one at each end. When not used for scheduled meetings, it serves as a lounge or lobby for the members.

One corner near the fire place is given over to a small, up-to-date library of scientific books. This arrangement encourages the teachers working on some problem in the field to check up on their problems immediately upon return to the building. In this small library, at the present, we have manuals to aid in the identification of trees, wild flowers, birds, and so on.

The kitchen is designed and equipped so that it will be possible to prepare and to serve food for 150 to 200 persons. The equipment is modern, but installed to be in keeping with the general plan of the Lodge.

The museum, located over the kitchen and reception hall with a balcony over-looking the main assembly room, serves several purposes. Smaller groups and committees can make use of this room with its fire place and general homelike atmosphere. When not in use for the foregoing purposes, it serves as a museum.

In the museum, cases have been designed with special lighting arrangement for the display of materials interpreting the local area as well as the more distant regions. The materials are frequently loaned by the members, and arranged by a special committee to illustrate certain themes. Here, the teachers may come and study the collections which frequently supplement the units of work in their class room. Some materials are being arranged for loan purposes to supplement the regular standard sets of visual materials. Recently, we have made available a collection of natural color lantern slides for use in the class room, or for clubs, or an evening's entertainment in the home. These colored slides include subjects such as a trip to Alaska, wild flowers, birds, trees, etc.

In the basement, we have given over two rooms to photog-

raphy. In the one, we have equipment for processing film, including 35 millimeters, the ordinary rolled film, film packs, and cut film. In the other room, our plan includes the installation of four different types of enlargers, such as the Eastman 5×7 Auto Foco, and a Leitz Vallroy enlarger for 35 millimeter film, an enlarger such as the Federal-120, or a Sun-ray for the size $2\frac{1}{4}$ and $3\frac{1}{4}$, and the 5×7 Special Universal Elwood enlarger. This provides for a wide range of negative sizes as well as great flexibility in the use of projection equipment. Printing boxes

Photograph by Ellis C. Persing Jr.

CLEVELAND NATURAL SCIENCE CLUB LODGE

for contact prints, automatic timer for connection with the enlarger, special paper negative outfits, such as the one distributed by the Willoughbys, are also in this room.

Even though we have the fireplaces in the assembly room and the museum, it seemed wise for so large a building to have a special heating device in the basement. With this plan of heating, we are enabled to use the building the entire year.

Since this building was designed to meet special needs of the club, we attempted to provide ample porch space for a membership of about 300. On the southeast side, we have a screened-

in porch, 60′ long, and 12′ wide. Joining this, we have an opened sun-porch about 12×12. Continuing to the southwest end, we have a porch about 12×24, and over this one is a deck porch which can be used for meetings, picnics, and social gatherings. In this way, we are able to take care of several different groups at the same time.

Extending from a terrace on the west side, we have a large play-area for such games as soft-ball, tennis, ping-pong, etc.

From the terrace, one follows the wide path through the shrubs and small trees for about 800 feet to the outdoor stove and picnic area. Here, we have facilities to take care of about 100 to 150 people. From here, we go to an open space in a wooded area which is arranged as an ampitheatre with log seats, a speaker's stand, and a screen for motion pictures and lantern slides. Here, we hold outdoor lectures dealing with scientific subject matter, travel, and recreation.

From the lodge, one follows an inconspicuous path through the forest to the public nature trail in the Metropolitan Park area which is maintained by the Cleveland Natural Science Club for the public.

We have a large committee of about twenty-five persons, well trained, and with a considerable background in the natural sciences. They find this work very stimulating.

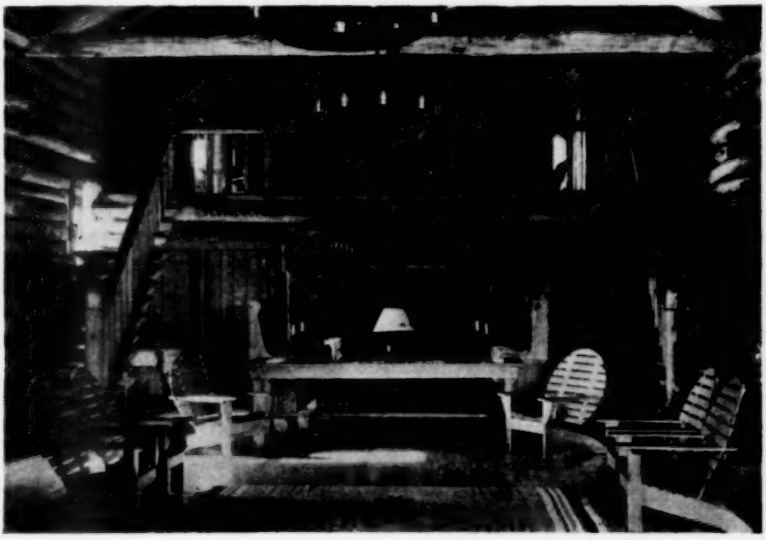
The program is extensive and varied. The club was originally organized to promote science education not only in the class room, but to offer a means for background subject matter. This idea applies not only to teachers, but to other persons interested in a type of public service for clubs—boy scouts and girl scouts and for life enrichment.

Accordingly, we have field trips throughout the year in order to acquaint the members more fully with the local areas. Special trips are designed for the study of wild flowers, trees, birds, ferns, geology, the ecological aspects of the vegetation, etc. Competent leaders are in charge of these trips, and help to keep the teachers informed on the seasonal development. Those persons interested in the out-of-doors as a hobby find here a source of inspiration and help.

The program of field trips has been extended to include week-end trips. This arrangement makes it possible to study areas such as the "Heart's Content" region in Pennsylvania which is a twenty acre tract of virgin forest. Other over-night trips have included "Cooks Forest" Region of Pennsylvania;

the "State Forests" in Hocking County, Ohio. On such trips, the emphasis is on ecological aspects of the vegetation.

In a large city, one is not likely to visit many of the outstanding points of interest unless there is some concerted effort by a group such as a club. The C.N.S.C. each year arranges a number of trips to include the industrial life of the city for teachers and other persons desiring to know their city. We have found the airport, the large hangar for dirigibles at Akron, Ohio; the flour mill, the oredock, the organ factory, and potteries ex-



Photograph by Ellis C. Persing Jr.

FIREPLACE AND BALCONY

tremely interesting in scientific background subject matter as well as practical applications.

No small part of the educational work is involved in maintaining the trail, writing the labels appropriate for the public, and keeping the labels arranged on the trail according to the seasons of the year. This work offers opportunity for twenty-five to fifty people.

The photographic section consisting of about fifty persons keenly interested in photography as a hobby, or in connection with their class room activities has an extensive program. Lectures and demonstrations are offered for the beginners. For the advanced worker, the program includes work in natural color,

paper negatives, etc. Meetings are held regularly each month at the lodge.

The travel section consisting of about fifty persons meets once a month to hear outstanding speakers or to discuss informally, the trips taken by the members. This section also sponsors trips to interesting areas in Ohio and to the neighboring states.

During the vacation months, members, because of their varied interest, travel to nearly all parts of the globe. As they go about, they are constantly on the lookout for outstanding and representative materials which illustrate some phase of the natural sciences. These materials, during the next year, serve as the bases of informal talks, and add considerable interest to the exhibits in the museum.

Future trips for this group include extensive traveling to such areas as Bryce, Zion and Grand Canyon National Parks, California, Mount Rainier, Glacier National Park and Alaska. Such trips will be of the nature of conducted tours for photographic purposes and scientific exploration. Such trips do much to help teachers make their class room work less abstract, and more concrete. Travel is an excellent means of obtaining background information and supplementary and enriching materials.

Formerly, the club consisted almost entirely of women teachers, but in recent years, people from the professions who are interested in the out-of-doors have associated themselves with this club. Likewise, the number of men has increased until now, we have a men's group consisting of about sixty teachers and professional men. They are planning an educational program to meet the specific needs. Lectures, field trips, and recreational activities are offered for the coming year.

The all-day fishing trip and over-night hike are also featured for next year's program. This group of men is just about as large as it should be to carry out the original idea, namely: informal group discussions. Thirty to forty people can easily gather around the camp fire or the fireplace in the assembly room, and listen to stories and discussions, questions of current interest, and exchange ideas on the interpretation of natural phenomena. With a group of this size, one is more likely to find a common interest or theme which will serve as the bases for activities. We have found, unless a group is keenly interested in achieving some objective or goal, that it does not carry on well. We like our groups to operate without any considerable degree of regimentation or forced attendance. Our speakers are

conscious of the appreciative audience, which we believe, is due to the motive prompting the attendance.

Recently, one of our prominent citizens made available a four-inch telescope. This instrument is serving as a theme and purpose for activities of another group which will probably develop into an astronomy section. The lodge is located in an area free from the electric lights so that observation and study with the telescope can easily be done. This group will be responsible for one or more programs during the year for the benefit of the whole membership. This offers the people interested in astronomy, a real purpose to crystallize and organize their findings for the lay-person. In this way, the section is also offering a service to the members, and the members, in turn, to the respective schools and parents of the community.

Plans are being formulated to offer short courses in such subjects as wild flowers, trees, birds, geology, etc. Such courses would not carry credit, and would be organized to supply background and specific information to the persons interested in the immediate interpretation of the local areas. Such courses should also appeal to the boy scouts, girl scouts, and camp leaders. Since the lodge is located in an area rich in biological and geological materials, it is the logical place to offer these courses. Since one of the objectives of this club is to promote instruction in the field of natural science, we have not neglected our obligation in the field of education. This group is affiliated with the National Science Teachers Association, and is entitled to one or more directors in that organization. This club realized the need for a section dealing with the problems of science in the elementary school. Accordingly, plans were formulated and presented to the North Eastern Ohio Teachers Association for approval. The first meeting of the new section was held in connection with the fall meeting last year. The attendance was beyond our expectation with the result that many teachers were turned away from the meeting, because of the limited space. Elementary science teachers were enthusiastic about the program, and the reaction has been most gratifying.

To meet the recreational and special interests of members, we have organized a folk-dancing section. This group meets regularly throughout the year, and they are learning the English and European folk dances as well as the American country dances. At least once a year, the folk-dancing group gives a public demonstration for the entire group.

The writer offers the information about this club in the hope that it will stimulate groups in other communities to attempt a similar project. The time and energy spent in this club is most worthwhile.

THE AMERICAN MATHEMATICAL SOCIETY ESTABLISHES A NEW PERIODICAL

The American Mathematical Society is in the fortunate position of having the financial backing, through the munificence of two of the great Foundations, to found a new international mathematical abstracting journal to be known as *Mathematical Reviews*. During the past quarter-century while the United States and Canada have been gradually assuming a more prominent part in mathematical research, there has been sentiment expressed from time to time among mathematicians that there should be a review journal sponsored by American organizations. But doubts as to whether the scientific and financial resources could be spared caused the postponement of the undertaking. However, the rapid growth of American mathematical resources and the availability of funds have resolved these doubts, and it has been decided to proceed immediately.

The first number of *Mathematical Reviews* is to appear late in 1939 or early in 1940; the material to be reviewed begins with the latter half of 1939. It is proposed to review all fields of pure mathematics and also those of applied mathematics and mathematical physics which are of pronounced interest to mathematicians. The new journal, which will be issued approximately once a month, will contain several thousand reviews annually and will run to approximately eight hundred large double-column pages. Professors J. D. Tamarkin and Otto Neugebauer will be the first editors. A strong group of collaborators for the initial period is assured.

The Carnegie Corporation has appropriated $60,000 as a backlog for the new journal. The Rockefeller Foundation has made a gift of $12,000 to cover some of the initial costs. Brown University is housing the project and aiding in the editorial work. The American Mathematical Society and the Mathematical Association of America are each starting off with a subsidy of $1,000 for the first year. Annual subsidies are being sought from other organizations, and plans for the permanent financing of the project are being considered. On account of the generous subventions, the subscription price will be set drastically below actual cost.

Partly with a view to aiding indirectly in the support of this journal, the Rockefeller Foundation has made a handsome gift to Brown University for an experiment in the dissemination of mathematical publications through the distribution of microfilm. This money is to be used to augment the mathematical library at that university, a collection which is already internationally known as outstanding. Out-of-print journals will be put on film and made available to mathematicians; rare books of general use will be filmed; on request from a subscriber to the new journal, any article reviewed will be sent on film or as film-print. This service will be extended to all parts of the world at a price not exceeding cost. It should be of greatest value to mathematicians located in the smaller universities and colleges and should be a factor in encouraging young men to continue with their investigations. This interesting experiment in the promotion of a new aid to learning should prove to be an asset not only to *Mathematical Reviews*, but also to American mathematics in general.

TEACHING FUNCTIONAL RELATIONSHIPS IN ELEMENTARY ALGEBRA

H. C. CHRISTOFFERSON
Miami University, Oxford, Ohio

At a time when arithmetic in the lower grades is being deferred and mathematics in the upper grades is being deleted or at least getting a decreasing percent of the high school enrollment, the order of the day between the National Council and the Central Association should be, not self seeking competition but co-operative competition, or perhaps competitive co-operation. We need to pull together, each to be a stimulus and a helper for the other. There is ample room for both organizations to do much to improve the teaching of mathematics as well as of science.

In a bulletin entitled *The Learning and Teaching of Algebra* Dr. Benz of Ohio University reports a study of 16,927 papers of the Ohio Every Pupil Test in Algebra, December 1930. In his conclusion after commenting on the tendency to begin algebra earlier, to base it largely on formulas, and to delete much of the formal manipulation he made the following statement. "There seems to be some basis for the suggestion that we teach less and that we teach it better.

"We ought to excuse some pupils entirely from the study of algebra. It will be noted on the general distribution that over 1000 pupils had scores under 10. Is it too much to say that there are 1000 children in Ohio taking algebra who should not be in the class at all, but might better be doing something else? The situation may be due to the fact that they are poor pupils, it may be due to poor teaching, it may be due to any one or more of many things, but the fact remains that they are getting practically nothing.

"In a few schools the teaching of the subject ought to be abolished until ways are found of teaching it better. If the most extravagant claims ever made for the teaching of algebra were true, the statement above would still be true, for it is very obvious that some pupils are not getting these values or any other. In some circumstances it may be said that we ought to stop wasting pupils' time or learn to teach our subject better."

This is a rather severe criticism.

It is not my purpose to read a lot of attacks on mathematics, even though they may be by outstanding mathematicians. Nor

is it my purpose to defend mathematics against such attacks. It is my purpose to advocate the use of functional thinking in the teaching of mathematics, because functional thinking is the major contribution of mathematics to the education of an individual. Such teaching would not be a panacea for all ills, but rather a method of emphasizing and obtaining insight and understanding; and a method which has great possibilities for making mathematical training more valuable.

Please know, however, that this is not a new idea. Permit me to quote from the very outstanding report of the National Committee on the Reorganization of Mathematics, written fifteen years ago.

"The one great idea which is best adapted to unify the course is that of the *functional relation.*

"The primary and underlying principle of the course should be the idea of relationship between variables, including the methods of determining and expressing such relationship. The teacher should have this idea constantly in mind, and the pupils' advancement should be consciously directed along the lines which will present first one and then another of the ideas upon which finally the formation of the general concept of functionality depends." In a later chapter of the same report Dr. Hedrick wrote a helpful and forceful statement.

"What is desired is that the idea of relationship or dependence between variable quantities be imparted to the pupil by the examination of numerous concrete instances of such relationship. He must be shown the workings of relationships in a large number of cases before the abstract idea of relationship will have any meaning for him. Furthermore, the pupil should be led to form the habit of thinking about the connections that exist between related quantities, not merely because such a habit forms the best foundation for a real appreciation of the theory that may follow later, but chiefly because this habit will enable him to think more clearly about the quantities with which he will have to deal in real life, whether or not he takes any further work in mathematics.

"To attain what has been suggested, the teacher should have in mind constantly not any definition to be recited by the pupil, not any automatic response to a given cue, not any memory exercise at all, but rather a determination not to pass any instance in which one quantity is related to another, or in which

one quantity is determined by one or more others, without calling attention to the fact, and trying to have the student 'see how it works.'"

In the September 1938 *Mathematical Monthly* Dr. Hedrick again discusses functional thinking in mathematics and claims that it is "the one theme which tends to unify all of mathematics and to permit its integration with life and with science." (p. 455)

In functional thinking, Dr. Hedrick explains, we ask two questions: (1) "Upon what quantities does the one quantity in which we are interested depend? (2) What is the precise manner in which it depends upon the other or others? If either of these questions is asked functional thinking is being done." (p. 448)

In the *3rd Yearbook* 1928 of the National Council Dr. Breslich has a masterful discussion of functional thinking and the *12th Yearbook*, 1934, by Dr. Hamley, is devoted entirely to the problem of functional thinking. In fact Hamley sets up a whole course organized upon this idea.

The Report of the Joint Commission, 1938, again indorses functional thinking as the core of secondary school mathematics especially grades 9, 11, and 12.

Enough of this defence for functional thinking. It shall now be my purpose to present to you specific concrete examples which emphasize the meaning and possibility of functional thinking.

There are many places in which every teacher even though he may not be conscious of it does do functional thinking. Whenever a teacher develops a formula, such as $A = bh$, $V = \pi r^2 h$, or $X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, he has answered the second of Dr. Hedrick's two questions. That is, he has shown just how one quantity is dependent upon another or others. All he needs to do is to point out to the student the fact that there is a relationship and to lead him to appreciate it. It is quite possible to use all these formulas mechanically and do no functional thinking.

Let me illustrate by the use of problems in which we seldom even approximate functional thinking and the above statement will be clear.

1. The problem of determining points in a contest for participants winning certain ranks.

Rank	Points
1	20
2	19
3	18
.	.
.	.
.	.
19	2
20	1

Possible Questions:

a. How many points would be won by a boy winning 8th place, or 16th place, etc.?

b. Since the number of points won in the contest is determined entirely by the rank of the contestant, there should be some systematic way of computing one from the other without making a table. Do you notice any relationship between rank and points? If so, express this relationship in a formula, using the letters r and p. $r+p=21$.

2. It used to be the practice in men's clothing stores to order the same number of shirts of each size needed. That meant that at the end of the year each store would have to put on a sale to get rid of the additional supply of shirts in odd sizes which were not sold. An intelligent buyer once made a study of the number of shirts of each size that was sold. He assembled these data in the form of a graph which seemed to be very near a normal curve.

After studying this graph, the buyer decided to buy shirts on the basis of the normal curve. There is reason to believe that shirt size is a variable the distribution of which would follow a normal curve. Apparently the relationship between size of shirt and number of people was one which could be expressed mathematically as a formula, and those of you who are familiar with the formula for a normal curve realize that the relationship is a complex exponential one. Sufficient, however, for the use of a buyer is a table giving the ordinates for about 7 or 8 points equally distributed on a normal curve.

The two illustrations given are unusual ones, and if I did not follow them by ordinary illustrations, you might feel that functional thinking could be used only in unusual situations. However, before bringing more illustrations, may I emphasize again the meaning of the term "functional thinking." Whenever two sets of quantities or two variables are so related that knowing one of them determines the other or enables one to figure out the other, we say that there is a functional relationship between the quantities. Whenever I am able to analyze this relationship to the point where I can express it as a formula or a graph, then I have completed my functional thinking, and produced usable results. Many formulas are provided and merely express in shorthand a rule which has been given in the textbook. These do not necessarily involve functional thinking when so obtained. I shall, therefore, obtain a few formulas from problems which

are not ordinarily solved by formulas. In order to emphasize the difference between functional thinking and expressing in a formula a rule is given in the book. May I also emphasize that functional or relational thinking with such simple formulas as $A=bh$ and $P=2b+2h$ can be done if emphasis is placed on the nature of the dependence, not merely upon expressing a rule as a formula.

3. If George can husk a load of corn in 4 hours, and Arthur can husk a load of corn in 3 hours, how long would it take the two boys working together? The answer as obtained by the ordinary technique is 12/7 of an hour. So far there has been little, if any, functional thinking. Let us now inspect the two numbers, 4 and 3, and the two numbers in the answer, 12 and 7. Any sort of an intelligent guess would determine by inspection the functional relationship which exists between the time it takes the two boys to do the job, and the time it takes each of the boys to do it alone. Try it out with other numbers. Demonstrate that the formula is correct by using letters instead of numbers, and you get a formula:

$$T=\frac{ab}{a+b}.$$

We have now done functional thinking twofold: (1) appreciating dependence and (2) expressing it.

4. Suppose Johnnie can do it in 5 hours alone. The three boys could then do it in how many hours?

$$\frac{1}{5}+\frac{1}{3}+\frac{1}{4}=\frac{12+20+15}{60}=\frac{47}{60}$$

$$T=\frac{60}{47}=\frac{a\cdot b\cdot c\cdot}{ab+ac+bc}.$$

5. A certain mash for hog feed is made by the prescription: 2 parts of corn to 3 parts of barley. How much corn and barley would one take to make 100 lbs. of the mash?

The ordinary algebraic solution solved the problem with 40 lbs. of corn and 60 lbs. of barley. Then analytic, functional, real thinking begins. Just what is the relation between the 40 lbs. of corn desired and the 2, the 3, and the 100? Even superficial analysis discloses the very simple relationship that 40 is $\frac{2}{5}$ of 100 and 60 is $\frac{3}{5}$ of 100. From this relationship, a formula could very easily be obtained such as

$$B=\frac{b}{b+c}\cdot W$$

and

$$C=\frac{c}{b+c}\cdot W$$

where B = the number of pounds of barley, C = the number of pounds of corn, b and c are respectively the number of parts of barley and corn.

6. A man wishes to add enough alcohol to 60 qts. of a 10% solution to make a 25% solution. How many quarts must he add? The solution of this specific problem involves some functional thinking, but such thinking is at its best when generalized into a formula or general rule.

$$x+.10(60)=.25(x+60)=.25x+.25(60)$$
$$x-.25x=.25(60)-.10(60)$$
$$x(1-.25)=60(.25-.10)=9$$
$$x=12 \quad \text{or} \quad x=\frac{a(c-b)}{100-c}$$

in which a, b, and c take the place of 60, 10 and 25 to make the solution general.

From these illustrations, it should be evident that functional thinking, which not only determines but ideally actually expresses the dependence which one variable has upon another or others, may be relatively simple, or it may be very complex. Those of us who have had more mathematics realize that it takes the calculus to express the relationships between variables in many cases. Let us now take some illustrations of a different nature. Time does not permit me to take more than two; one from arithmetic, and one from algebra. It is evident from the above illustrations that practically every problem solved in algebra does have a general solution such as indicated above, and therefore, every problem in algebra could serve as material for functional thinking.

Let us study two simple problems of a different nature.

7. Add the fractions $\frac{2}{3}$ plus $\frac{3}{4}$, and one gets 17/12. Is it possible from this answer to analyze the relationship between 17/12 and the various numbers which express the fractions to be added? Surely the answer is determined by the numbers which form the fractions. If any one of those numbers is changed, the answer would be changed. A simple formula can be used to express this relationship.

$$\frac{a}{b}+\frac{c}{d}=\frac{ad+bc}{bd}.$$

8. In the solution of two simultaneous linear equations such as

$$3x+5y=11$$
$$2x+7y=13.$$

It is evident that the values of x and y are wholly dependent upon the numbers, 2, 7, 13, 3, 5, and 11. Furthermore it should be possible to discover and express that relationship.

Solving, we have

$$\begin{array}{r} 6x+10y= \quad 22 \\ 6x+21y= \quad 39 \\ \hline -11y=-17 \end{array}$$
$$y=\frac{17}{11}$$

The 17 came from 39 and 22 and these numbers in turn from 3×13 and 2×11. The 11 in the denominator came from 21 and 10 and these in turn from 3×7 and 2×5, or

$$y=\frac{3\times13-2\times11}{3\times7-2\times5}.$$

Furthermore

$$x=\frac{12}{11} \quad \text{or} \quad \frac{7\times11-5\times13}{3\times7-2\times5}.$$

Note the same denominator. Putting this in a familiar form,

$$\begin{cases} y=\dfrac{\begin{vmatrix} 3 & 11 \\ 2 & 13 \end{vmatrix}}{\begin{vmatrix} 3 & 5 \\ 2 & 7 \end{vmatrix}}=\dfrac{17}{11} \\ x=\dfrac{\begin{vmatrix} 11 & 5 \\ 13 & 7 \end{vmatrix}}{\begin{vmatrix} 3 & 5 \\ 2 & 7 \end{vmatrix}}=\dfrac{12}{11}. \end{cases}$$

It is evident that determinants are but a formula for expressing the functional relationship between the unknowns and the constants.

In conclusion, the idea of determining the relationship which exists between quantities with which we deal is one of a fundamental mathematical nature. It is one which is interesting to children and it is one which should produce large dividends in terms of mathematical appreciation, mathematical reasoning, and mathematical insight.

It has been the purpose of this paper to emphasize functional thinking for mathematics teaching, and to recommend for those teachers who are more concerned with the education of children than with merely covering the material in a textbook that they experiment with this stimulating, somewhat elusive, yet tremendously simple and satisfying concept.

AMERICAN EDUCATION WEEK 1939

The 1939 American Education Week observance will be held November 6–11, 1939. "Education for the American Way of Life" is the general theme. As in previous years the National Education Association has prepared materials to assist schools in planning for this observance including colorful posters, leaflets, stickers, and packets containing special folders for the different school levels prepared by field committees in various sections of the United States. Useful alike to the classroom teacher, principal, superintendent, or American Education Week committee. Early planning will help you make your observance most effective. For complete information, write to the National Education Association, 1201 Sixteenth Street, N. W., Washington, D. C.

FINDING CANDLE POWER WITH A SIGHTMETER

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There are available today certain devices which can be adapted to the measurement of candle power, and which, because of their direct reading, are not as subject to error as those instruments which require a judgement of the brightness of light by means of the human eye. I refer to the devices which use a photoelectric cell and a galvanometer to measure the intensity of light. These instruments occur in several forms, the most common being a foot-candle meter or "sightmeter" used by illumination engineers, and the exposure meter used by so many camera fans. It is a rare community in which one or the other of these devices cannot be found, and the owners are usually willing to loan them to responsible teachers for a few days. The following laboratory demonstration was developed for the purpose of finding the candlepower of various sources of light.

Problem: To measure the candle power of a lamp using a foot-candle meter or an exposure meter.

Implication: The alarming prevalence of eye defects in our population renders it imperative that we attack the problem of inadequate lighting in our schools, homes, and places of employment. This can probably best be accomplished by, providing students with an experience in the use of the tools that science has produced, and by developing in them an appreciation of the value of these tools and a confidence in the results obtained with them.

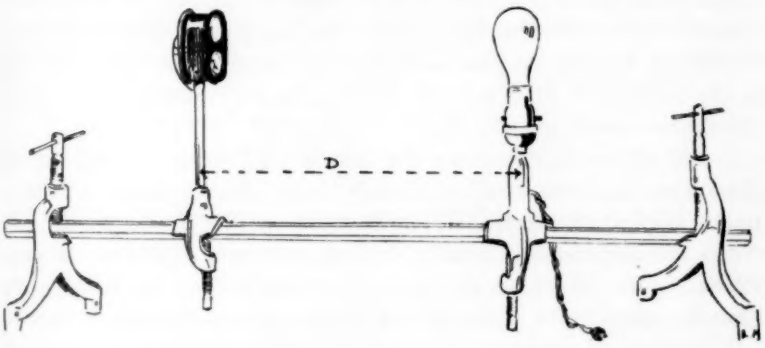
Apparatus: Meter stick with supports or optical bench, foot-candle meter, candle, various sized Mazda lamps. Socket mounted on a sliding support, and any other available lighting equipment.

Discussion: The Weston photoelectric cell generates a minute current of electricity whenever light falls upon its sensitive surface. The strength of this current is dependent upon the amount of light that falls on the cell. Therefore, when the output of the cell is measured by a sensitive galvanometer, the reading of the meter is directly proportional to the intensity of illumination of the cell. In the foot-candle meter or sightmeter the scale is calibrated in terms of foot candles instead of milliamperes, and this makes it possible to use the meter to find the candle power

of any source of light. The following illustration and procedure makes use of a foot-candle meter or sightmeter.*

Part I: Measuring Candle Power with a Foot-Candle Meter

Procedure: A. Place a 25 watt bulb in the socket and attach the foot-candle meter to the meter stick at some convenient point so that the center of the sensitive area is at the same level as the center of the light bulb. Turn on the light and rotate the globe until the maximum deflection is obtained. (Why does one side of the lamp give off more light than the other?) Then move



the lamp toward the cell until the meter registers some convenient value as 20 foot candles. Carefully measure the distance of the lamp from the cell in centimeters. Then divide this value by 30.48 to change it to feet. (Why must we use feet?) Now we have a lamp which produces 20 foot candles on a surface at some known distance from the lamp. To find the candle power we have only to substitute these values in the formula: Candle Power = Foot Candles $\times$ (Distance)^2. (This formula is derived from the usual illumination formula: Foot Candle = C.P./D^2.) Using the data found, calculate the candle power of the 25 watt lamp.

B. Replace the 25 watt lamp with a 40 watt and again take the readings and calculate its candle power. (Do not forget to rotate the lamp to obtain the maximum amount of light.) In

* A few simple precautions will remove any necessity of a darkroom or light tight box for the carrying on of these exercises. Use two, two-foot squares of cardboard covered with black cloth and set up to form a narrow V; then face the cell in the direction of the apex of the V and away from the windows or other sources of light. In all but the very lightest rooms it is not necessary to draw the shades as the effect of incident light on the cell is usually so small that the meter does not register its intensity. It is necessary however to remove any light colored objects from the vicinity of the cell as even your hand placed in the proper position will reflect enough light to register on the meter.

a like manner, find the C.P. of a 60 watt, 100 watt, and 200 watt lamp.

C. Find the candle power of an ordinary candle.

D. Measure the C.P. of an old style carbon lamp. If possible measure the watts consumed by this lamp and record.

E. Measure the C.P. of a cheap imported lamp, and also its consumption in watts.

F. With a pencil, mark the side of a 60 watt lamp that gives off the most light, then rotate the lamp 90° and find the C.P. Rotate another 90° and again find the C.P. Rotate another 90° and calculate the C.P. Remove the lamp and holder from the bench and turn it so that the side opposite the socket is toward the cell. Measure the C.P. while the lamp is in this position. (What is meant by "mean spherical candle power?") What is the average C.P. given off by this lamp? Compare this with the value found in part B.

G. Replace the lamp on the bench and move it back until the meter registers 10 foot candles. Now place a sheet of white paper behind the lamp. (What happens to the meter reading?) Bend the paper to form a U-shaped reflector behind the lamp. (What is the effect on the meter reading?) Why do flashlights give so much light with such a small current consumption?

Calculate the candle power per watt for each of the sources of light used and record in the proper column. This factor is sometimes used as an expression of the efficiency of the lamp.

DATA

Lamp	Foot Candles Developed	Distance	Candle power	Candle Power per Watt
25W				
40W				
60W				
100W				
200W				
Carbon				
Candle				
Other				
Other				

Questions:

1. How do the efficiencies of the smaller lamps compare with those of the larger lamps? .....
2. How does the efficiency of the Mazda lamp compare with that of the Carbon? .....
3. How does the efficiency of the Mazda lamps compare with that of the cheap imported variety? .....

Part II: Measuring Candle Power with an Exposure Meter

Procedure: The exposure meter uses the same type of photoelectric cell as the sightmeter but is calibrated logarithmically in numbers denoting light intensity. Therefore it is necessary to use a standard candle power lamp and compare the other light sources with the standard.

Set up the optical bench as in Part I and attach the exposure meter in the place of the sightmeter. Place the standard candle power lamp in the light socket and by means of a rheostat and voltmeter adjust the voltage across the terminals of the lamp to the correct value specified for that lamp. Move the lamp along the bench until the exposure meter indicator points to some reading near midscale or #50. Now carefully measure the distance in centimeters from the center of the cell to the center of the lamp, and record in the data table under the heading (Distance Standard). Record also the candle power of the lamp under the heading (C.P. Standard). These readings will remain constant throughout the exercise.

Replace the standard lamp with a 25 watt Mazda and rotate it on a vertical axis until the maximum deflection is produced on the meter scale, then shift its position along the meter stick or bench until the intensity of illumination on the photocell is the same as that which was produced by the standard. This is indicated by an identical meter reading. Measure the distance from the lamp to the cell and record in the data table under the heading (Distance Unknown). Now if the unknown lamp is brighter than the standard lamp the (Distance Unknown) will be greater than the (Distance Standard), but if it is less intense than the standard it will of necessity be nearer the cell to produce the same illumination. Now since the meter readings are the same in both cases, the intensity of illumination on the cell must also be the same in both cases. Thus we have two different lamps producing an equal amount of illumination at a

given point but of course at different distances from the point. Now the illumination produced by a lamp at any given point equals the candle power of the lamp divided by the square of its distance from the point. Stated in formula this equals: Illumination $= \frac{\text{Candle Power}}{D^2}$. But the illumination in each case is the same. Therefore,

$$\frac{\text{C.P. Standard}}{(\text{Distance Standard})^2} \text{ equals } \frac{\text{C.P. Unknown}}{(\text{Distance Unknown})^2}.$$

To find the C.P. of the 25 watt Mazda we have only to substitute the values already observed, in the above equation and solve for the unknown candle power. Perform this calculation and record in the data.

Using the same method find the C.P. of, a 40 W, a 60 W, a 100 W, a 200 W Mazda, a candle, a carbon lamp, and a cheap imported lamp.

Using the procedure given in Part I, measure the average candle power of a 25 W lamp and compare this value with the maximum candle power.

It is obvious that the consumption in watts of any lamp depends materially on the voltage that is impressed on the filament of the lamp. Now the heating effect of an electric current varies directly with the square of the voltage, so even a small voltage change will result in a marked change in temperature and therefore light output. Since the voltage varies widely from city to city and sometimes as much as several volts within cities and at different times of the day, it is wise to measure the actual watt consumption of the lamps used in this exercise. This requires a 125 volt A.C. voltmeter connected across the terminals of the lamp and a low range A.C. ammeter connected in series with the lamp. The product of the voltage and the amperage will give a watt rating whose accuracy depends on the quality of the instruments used.

USES OF THE PERSIMMON TREE

Persimmon trees have a threefold importance: their wood is ideal for golf club heads and similar small objects, their fruit is one of the most important wildlife foods, and their tough, ropelike roots made them favorites with soil conservation workers as plantings to check erosion.

SCIENCE FOR LEISURE TIME

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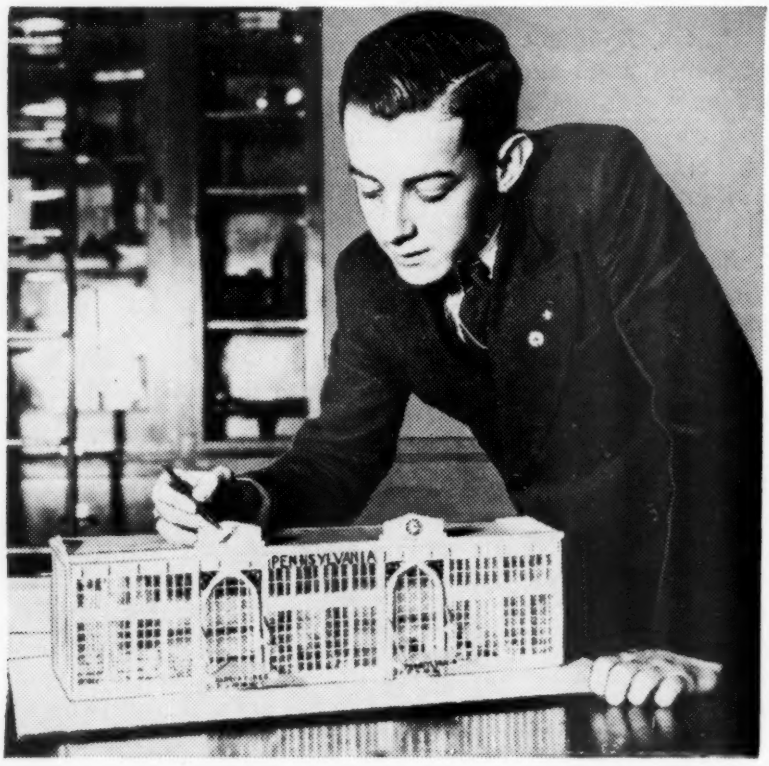
Irvington High School, Irvington, New Jersey

Undoubtedly the greatest possible value in a well-planned science-teaching program will depend considerably upon the ability of the teacher to make the subject-matter appealing to the varied interests and felt needs of the individual. If these interests are stimulated, the learning process will be improved. One way to awaken the latent interests, especially in junior-high-school science, is to have pupils of special aptitudes make projects relative to a lesson unit. Once the enthusiasm is aroused, the task of broadening becomes comparatively easy under good guidance. The progressive teacher will always look upon this practical activity as a continued discovery and development of pupil potentialities.

It is due to a long-expressed desire by teachers, asking for a list of leisure-time projects adaptable to the junior-high level, that this article is written. Since desirable picture aids for individual or group exhibits are often quite difficult to acquire, the chief purpose of the present study is to give only the exact source for scientific materials that are easily obtainable and well illustrated. No attempt is made to give directions for construction. This specific information, in many cases, will free the busy teacher from continuous visits to museums, libraries, expositions, hobby shops, industries, and some department stores in search for unexplored subjects. One will observe at these displays that airplanes and radios are much overworked, and therefore are less likely to receive certificates of merit as some others whose frequency of appearance is considerably less. The carefully selected projects offered in the bibliography are found to be practical and workable; at the same time they constantly challenge the skills and initiative of the individual. Furthermore, the materials needed are available and inexpensive.

The greater portion of these activities have actually developed from work in the writer's ninth-grade general science classes and have been exhibited at the State Science Fairs, State Science Association Meetings, and our annual school science exhibits. It is a well-attested fact that one of the most common causes for the apparent waning interest of project-making is the failure on the part of the teacher to develop new

subjects. Therefore, creativeness especially for the earning of awards and prizes in exhibits is always highly essential. Below is a pictorial example of this originality,[1] a project exhibited at the North Jersey sectional conference of the State Science Teachers Association.



Courtesy, *Newark Sunday Call*

EDWARD WOOD, Irvington High School, points to the insignia on his model of the Newark Pennsylvania Railroad Station.

Needless to say, the teaching of science will be enriched, and learning facilitated through the creation of some unusual and up-to-date projects. Likewise, science education will be made more effective because these pupils will come into direct contact with objects and phenomena which they wish to learn about. No longer can we as teachers expect to have the support of public funds if the result of the student's work remains in-

[1] Simmons, Maitland P., "Originality in Scientific Models," *Science Education*, Vol. 22, No. 4 (April, 1938), p. 195.

tangible. Our schools, especially in these grades, can produce something that is of vital significance to the adolescent in this present-day world.

It is hoped that the following suggestive list will furnish a good starting point for further stimulation in class projects.

Activity Units

UNIT I: AIR

Project 1—A Great Workshop Under Water: A Caisson
Caldwell, O. W. and Curtis, F. D. *Science for Today* (Boston: Ginn & Co., 1936), pp. 49–51. ill. E.[2]

Project 2—A Famous Experiment: Otto von Guericke's Demonstration with His Two Hollow Hemispheres[3]
Caldwell, O. W. and Curtis, F. D. *Science for Today* (Boston: Ginn & Co., 1936), pp. 40–41. ill. G.

UNIT II: THE EARTH'S CRUST

Project 3—Carving the Great Stone Faces in the Granite of Mount Rushmore
Borglum, Gutzon, "A Monument That Is a Mountain," *The Rotarian*, Vol. LII, No. 5 (Chicago: Rotary International, May, 1938), pp. 36–37. ill. E.

Project 4—Homes of the Cliff Dwellers.
Caldwell, O. W. and Curtis, F. D. *Science for Today* (Boston: Ginn & Co., 1936), p. 361. ill. G.

Project 5—The Most Perfect Volcano, Mount Mayon, Philippines
Gruenberg, B. C. and Unzicker, S. P. *Science in Our Lives* (Yonkers, N. Y.: World Book Co., 1938), pp. 316–17. ills. E.

Project 6—The Work of Underground Waters: Carlsbad Cavern, New Mexico
Skilling, W. T. *Tours Through the World of Science* (New York: McGraw-Hill Book Co., Inc., 1934), pp. 203–06. ill. G.

Project 7—Model of an Oil Gusher
Bowden, G. A. *Foundations of Science* (Philadelphia: P. Blakiston's Son & Co., Inc., 1931), pp. 207–09. ill. G.

UNIT III: FORCES OF NATURE

Project 8—The Effect of Gravity: Leaning Tower of Pisa in Miniature
Meister, Morris, *Living in a World of Science* (New York: Charles Scribner's Sons, 1935), p. 111. ill. G.

Project 9—The World's Mightiest Dam: Boulder Dam[4]
Wood, G. C. and Carpenter, H. A. *Our Environment: The Living Things In It* (Boston: Allyn and Bacon, 1938), p. 241. ill. G.
Salt, Harriett. *Mighty Engineering Feats* (Pa.: The Penn Publishing Co., 1937), pp. 231–64. ill. G.

[2] Refers to illustration as E., excellent; G., good; F., fair. This rating is intended to show the practicability of the pictures used in project construction. It is in no way a criticism of the illustration.

[3] Simmons, Maitland P., "Their First Scientific Project," *Science Education*, Vol. 22, No. 6 (November, 1938), pp. 310–11.

[4] Use all references.

"Harnessing America's Wildest River," *Popular Mechanics*, Vol. 71, No. 2 (Chicago: Popular Mechanics Co., February, 1939), pp. 200–04, 118A–19A, 21A. ills. G.

"A New Rival to the Grand Canyon," *Travel*, Vol. LXIX, No. 4 (East Stroudsburg, Pa.: Robert M. McBride & Co., Inc., August, 1937), pp. 18–19. ills. F.

UNIT IV: THE UNIVERSE

Project 10—Progress in the Measurement of Time

Wonders of Progress (New York: Metro Publications), p. 3. ill. E.

UNIT V: LIGHT

Project 11—An Eternal Light: Edison's Tower in Miniature[5]

"The Progress of Science," *The Scientific Monthly*, Vol. XLVI, No 4 (Lancaster, Pa.: The Science Press Printing Co., April, 1938), pp. 387–89. ill. E.

Webb, H. A. "An Eternal Light," *Current Science*, Vol. XIII, No. 20 (Columbus, Ohio: Education Press, Inc., Feb. 7–11, 1938), p. 82. ill. F.

Project 12—A Model of Mount Palomar Observatory, California

Pryse-Jones, "Building the World's Largest Telescope," *Travel*, Vol. LXVIII, No. 4 (East Stroudsburg, Pa.: Robert M. McBride & Co., Inc., February, 1937), pp. 36–40. ill. E.

"Wonders of Astronomy," *Popular Mechanics*, Vol. 71, No. 2 (Chicago: Popular Mechanics Co., February, 1939), pp. 177–84, 128A–29A. ill. F.

UNIT VI: TRANSPORTATION

Project 13—A Miniature Reproduction of the Golden Gate Bridge

Crowe, M. H. "Singing Bridges," *The Rotarian*, Vol. LII, No. 5 (Chicago: Rotary International, May, 1938), pp. 28–31; 61. ills. E.

Saunders, Edwin. "The World's Greatest Suspension Bridge," *Travel*, Vol. LXIX, No. 1 (East Stroudsburg, Pa.: Robert M. McBride & Co., Inc., May, 1937), pp. 18–21; 53. ills. G.

Project 14—The Modern Transatlantic Liner: Queen Elizabeth

"Latest Liner is Larger than the Queen Mary," *Popular Mechanics*, Vol. 71, No. 1 (Chicago: Popular Mechanics Co., January, 1939), pp. 62–63. ills. G.

Project 15—Dr. Beebe's Bathysphere in Miniature

Beebe, William. "A Half Mile Down," *National Geographic Magazine*, Vol. LXVI, No. 6 (Washington: National Geographic Society, December, 1934), pp. 661–704. ills. E.

Project 16—The Gatun Locks, Panama Canal[6]

Davis, I. C. and Sharp, R. W. *Science* (New York: Henry Holt & Co., 1936), p. 13. ill. E.

Salt, Harriett. *Mighty Engineering Feats* (Pa.: The Penn Publishing Co., 1937), pp. 51–76. ill. E.

Hunter, G. W. and Whitman, W. G. *Science in Our World of Progress* (New York: American Book Co., 1935), p. 262. ill. G.

Project 17—Development in Road Construction: Modern Superhighways

Hunter, G. W. and Whitman, W. G. *Science in Our World of Progress* (New York: American Book Co., 1935), pp. 250–53. ills. E.

[5] Use both references.

[6] Use all references.

UNIT VII: ELECTRICITY

Project 18—Communication through the Ages

Meister, Morris. *Living in a World of Science* (New York: Charles Scribner's Sons, 1935), p. 53. ill. E.

Davis, I. C. and Sharp, R. W. *Science* (New York: Henry Holt & Co. 1936), p. 248. ill. E.

UNIT VIII: ANIMAL LIFE

Project 19—A Story of Changes in the Human Skull

Eikenberry, W. S. and Waldron, R. A. *Educational Biology* (Boston: Ginn & Co., 1930), pp. 502–09. ill. E.

Project 20—Prehistoric Animals

Davis, I. C. and Sharpe, R. W. *Science* (New York: Henry Holt & Co., 1936), pp. 5; 433. ills. E.

THE CLASSROOM FILM

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In the April number of SCHOOL SCIENCE AND MATHEMATICS, H. Emmett Brown lists twenty-seven "consumer grievances" against classroom films. Although he states in his introductory paragraph that the criticisms are not valid of all films, nor of all producers or proponents of visual education, he leaves the impression, that in general, the use of classroom films is a woeful waste of good time and good money. He offers no constructive criticism or constructive ideas to better the conditions he berates so soundly.

As one who has used classroom films in the teaching of chemistry, I wish to present a more hopeful view of the situation. Properly used, carefully selected motion pictures have won a well defined place in the teaching of science, and their use needs no defense.

The use of motion pictures is comparatively new in education, and mistakes have been made, and are still being made, but conditions are rapidly improving. One has only to compare conditions as they existed three years ago with conditions as they are today to see what has been accomplished.

Every advance always suffers from its too enthusiastic friends. That has been true of the use of films in schools. Educators, noting how much the exploits of Tarzan and the Lone Ranger entered into the lives of Young America, hailed the

motion picture as the solution of all of their ills. With very little evidence, extravagant claims were made. Time and effort would be saved in presenting difficult concepts, and because we could catch the interest of the pupil, we could fill him with knowledge in a painless manner, in a short time. Time would thus be saved for the teacher, for the film did the teaching. Fortunately the movement has been going long enough so that the wide eyed enthusiasts have tired of films and are seeking other new panaceas, leaving the development of the idea to the more practical workers in the field.

When this movement was new there were no real educational films. Producers presented advertising films, and cut and edited certain theatrical films. Many advertising films are no more educational films than a bill board is a work of art fit to adorn an art gallery. In the absence of more satisfactory material these were introduced into the classroom, with not very satisfactory results. Soon the demand for real educational films was sufficient to cause the producers to put out films designed only for teaching purposes. The pioneers in this movement with no precedents to guide them, made some mistakes, but at present the films are much better and improvements are constantly being made.

It is impossible to produce a picture that will please every teacher. What one teacher may wish to emphasize another will consider of minor importance. However, with some real teachers as consultants, the quality of the films as teaching devices is showing a great improvement.

What should we expect from a motion picture in the classroom? First, we should not expect it to take the place of a teacher. No substitute for a real live teacher has yet been found. We must look to the teacher and not the film, for inspiration, and for ideas that will stimulate the imagination of the pupils. Attempts to do this on the film are not always successful, and sometimes give an effect which is resented by the pupil. The "Ain't Science wonderful" attitude provokes antagonism rather than inspiration. The personality of the teacher can put across the idea of the Romance and marvels exhibited on the screen, but when the words appear in type or come from the voice of some unknown commentator, the effect is lost. Along this line it is interesting to note that the magazine, *The Business Screen* states that there are twenty-one films whose title begins the "Romance of . . ."

In the science class the motion picture is especially valuable in showing certain types of experiments that the busy teacher has no time to prepare. The experiments dealing with the combining volumes of gases to form the basis for the formulation of Gay Lussac's law, can be shown in a few minutes, while the setting up of these experiments takes hours of time. There are certain types of apparatus that are not commonly found in a high school laboratory that can be shown on the screen in such a manner that the pupil can get a definite idea of the procedure.

Science classes in some city high schools are getting so large that visits to industrial plants are a practical impossibility. Several Chicago high schools have more than 500 pupils in chemistry classes. No manufacturing plant cares to act as host to quite so large a visiting group. We believe that our pupils should know how operations of a chemical nature are carried on in industrial plants. If we can't go to the factory, we can bring the factory into the classroom, on the screen. If these films use animated diagrams, the pupil may learn more than he would have learned on a visit to the plant. Some of these films dealing with industrial processes sometimes show masses of machinery and tools that at first seem quite confusing. If these films are considered as giving a view of vocations, this footage is not wasted. It is worth while for a boy to see under what conditions he must work if he enters certain industries. Considered from this point of view these films have real vocational value.

Recently some very excellent films have come out containing some wonderful microscopic photography. Microscopes are expensive and microscopic technique is difficult for adolescents. The use of these films makes certain that each pupil will see what he is expected to see, without having his attention distracted by the mechanics of managing a microscope. It makes certain also that all students see the same thing, and the teacher can point out things he wishes to emphasize as the film is shown on the screen.

By the use of slow motion or time lapse pictures, impressions can be made that the pupil will never forget. If a pupil in botany has ever seen the time lapse picture of a growing twining vine, he will never forget it. To see the vine put out leaves and swing around its support leaves an indelible impression on the mind of the student. If the football coach wishes to show how a play should be performed, by the use of a slow motion picture, he can cut down the rapid motion so that the position and action

of each player can be clearly seen throughout the play. In a zoology class a slow motion picture of birds in flight shows the motion of wings in a manner that can be obtained in no other way.

In geography classes the film brings the reality of life into far distant places. Only a short time ago while in Washington, I talked with a high school girl from the south who was on a tour with a high school class. She said "I feel quite at home here. You know I have seen Washington in the movies."

If your 8th grade pupil can say as much of China or Mexico or London, he is getting more out of his geography than people a generation or so ago ever were able to get.

No teacher needs to use poor films that do not teach a lesson. There are so many good films now that he can choose those that are suited to his class, and to his needs. Before any film is presented to a class, the teacher should run it and know what he is showing. He should familiarize himself with its details and be able to offer comments where they are needed. The film should be followed by such discussion and testing, that the class will not feel that it is being given only for entertainment or to kill time. The student must not expect that an educational film is going to end in a dramatic climax as does the serial shown on Saturday afternoon at the neighborhood "movie palace."

The teacher must realize that the classroom film has its limitations. It cannot be used to teach everything. In some cases slides and a lantern may be used to better advantage. Projectors and films are expensive, and in some localities the difficulty and trouble of getting the proper film just when it is needed, greatly restricts its use.

Circulating film libraries are in operation, and the film catalogues give rather definite information as to the nature of the films available. With the rapidly improving conditions we may look forward to an increased efficiency in the use of films in the classroom.

The use of films will not lessen the teacher's load. It may increase it some, but the classroom film has become a regular tool in the teaching of science in the modern high school. Careful tests have shown its efficiency in instruction. To make it still more valuable we must have co-operation between teacher and producers, so that films better adapted to classroom use will be available.

ON NECESSARY AND ON SUFFICIENT CONDITIONS IN ELEMENTARY MATHEMATICS[1]

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The emphasis of this paper lies on the distinction between necessary conditions and sufficient conditions.

If I, a teacher at Notre Dame, am to present a paper in Chicago, then it is necessary that I come to Chicago. My coming to Chicago is a necessary condition for my presenting a paper in Chicago. But my coming to Chicago is not sufficient for my presenting a paper. I may come to Chicago just in order to see the art gallery without presenting a paper.

If I read before you a typewritten manuscript, this is a way of presenting a paper. My reading a manuscript is a sufficient condition for my presenting a paper. But it is not a necessary condition—I may present a paper without reading a manuscript by an impromptu talk.

If a statement S implies a statement C, that is to say, if the truth of S is incompatible with the falsehood of C, then we call C a necessary condition for the statement S. If conversely, the statement C implies the statement S, then we call C a sufficient condition for the statement S. To mix up the necessity and the sufficiency of a condition means to confound a statement with its converse. Primitive logical mistakes of this type should be avoided in each field of discussion, especially they should be avoided in mathematics.

Yet in former times even great mathematicians did not quite escape this confusion, a fact that served actually to hinder the development of some branches of higher mathematics. Today this fact is only of historical interest for in research of our time logical rigor has reached a degree which precludes any confusion of the above mentioned type.

It is different with the teaching of mathematics, however. In a great number of texts dealing with all parts of mathematics (the most elementary branches, algebra, geometry and the calculus) the mistake is still to be found, and almost in full bloom today. Let me illustrate this fact by a few very simple examples.

[1] Presented to the Mathematics Section of the Central Association of Science and Mathematics Teachers, November 25, 1938.

Let us consider the linear equation in one unknown[2] $3x+2=0$. In solving this equation most textbooks proceed in the following way:[3] By applying the law that equals subtracted from or divided by equals lead to equal results, they conclude from the equation that $3x=-2$ and $x=-2/3$. Thus, they say, $-2/3$ is the solution of the equation. This argument is wrong, being based on the confusion of the necessity and the sufficiency of a condition. What is actually proved is this: if a number x satisfies the equation $3x+2=0$, then this number is equal to $-2/3$; in other words, $x=-2/3$ is a necessary condition for the solution x of the equation $3x+2=0$. But if we say that $-2/3$ is the solution of the equation $3x+2=0$, we mean that, conversely, if a number x is equal to $-2/3$, then this number satisfies the equation; in other words, we mean that $x=-2/3$ is a sufficient condition for the solution x of the equation $3x+2=0$. This latter statement happens to be true but in order to prove it, we have to proceed in the following way: We have to multiply the number $-2/3$ by 3, then to add the number 2, and to show that the result is 0. This argument is quite different from the one which leads to the necessity of the condition and which is erroneously taken as a proof of the fact that $-2/3$ is a solution of the equation.

Should one thus omit the usual proof for the necessity and merely teach the above-mentioned proof of the sufficiency? By no means. With such a procedure the student would not understand why just $-2/3$ is the solution. What should be taught, I think, is just the truth which consists of two parts:

(1) If a number x is a solution of the equation $ax+b=0$, where $a\neq 0$, then this number is necessarily $-b/a$. This statement which has to be proved in the ordinary way shows that certainly no number different from $-b/a$ can possibly be a solution of the equation.

(2) If the number x is equal to $-b/a$, then this number is the solution of the equation $ax+b=0$. This statement which has to be proved by substituting $-b/a$ into the equation shows that $-b/a$ actually is the solution.

The difference of the two parts becomes quite clear if we argue in the following way: If the number x satisfies the equation $3x+2=0$, then $3x=-2$, thus (by squaring equals) $9x^2=4$,

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[2] If a and b are two numbers ($a\neq 0$), then the condition $ax+b=0$ imposed on a number x is called a linear equation for the unknown x.

[3] As one of the exceptions I quote H. B. Fine's *College Algebra* (Ginn and Company).

consequently $x^2=4/9$ and $x=2/3$ or $-2/3$. In other words, we prove by a perfectly correct argument that if a number x is solution of the equation then x is necessarily equal to either $2/3$ or $-2/3$. By a correct proof we demonstrate that a solution of the equation satisfies the necessary condition of being either $2/3$ or $-2/3$. This necessary condition, however, is not sufficient. If $x=2/3$, then $3x+2=4$, not $=0$. Here is a simple case of the correct derivation of a necessary but not sufficient condition. This situation shows clearly that the ordinary proof of the first necessary condition which turns out to be also sufficient has to be supplemented by a proof of its sufficiency.

The situation is quite similar in the case of two linear equations with two unknowns,

$$ax+by=m,$$
$$cx+dy=n.$$

The ordinary method of solving these equations consists in multiplying the first by d and the second by b, and in subtracting the second from the first. In this way we get $(ad-bc)x=dm-bn$ and in a similar way we get $(ad-bc)y=an-mc$. Most textbooks conclude: Thus, if $ad-bc\neq 0$, then

$$x=\frac{dm-bn}{ad-bc}, \qquad y=\frac{an-cm}{ad-bc}$$

constitute the solution of the two equations. Again the necessity and the sufficiency of a condition are confounded. What is actually proved is that if two numbers x and y satisfy the two equations in two unknowns, then these two numbers are necessarily equal to the above-mentioned quotients. In other words, no numbers different from the above-mentioned quotients can possibly solve the two equations. But by saying that these two numbers are actually the solution of the equations we state the converse of what was just proved: we say that if two numbers have the above-mentioned values, then they satisfy the two equations. This happens to be true, but again it has to be proved separately by substituting these two numbers into the equations and showing that they satisfy them. Again it would be easy to derive, by perfectly correct arguments, conditions for the solutions which are necessary without being sufficient.

I hardly need to say that similar criticism may be applied to the proofs presented in the theory of systems of more linear

equations in more unknowns, and also to the proofs concerning the solution of quadratic equations.

So far we discussed the error of taking a necessary condition for sufficient. In dealing with quadratic equations some authors commit the opposite mistake by taking a sufficient condition for necessary. Let us consider the quadratic equation $x^2-3x+2=0$. Suppose it has been proved that $x^2-3x+2=(x-1)(x-2)$. Basing on the theorem that if at least one factor of a product is equal to 0, then the product is equal to 0, we can correctly conclude that $x=1$ and $x=2$ are solutions of the equation. In fact, substituting for x either of these values we make equal to 0 one factor of the product $(x-1)(x-2)$ and thus the product and hence the polynomial x^2-3x+2. In other words, to be equal to either 1 or 2 is a condition sufficient to guarantee that a number is a solution of this equation. But this argument does not yet prove that 1 and 2 are the only solutions of this equation. It does not prove that to be equal to either 1 or 2 is a necessary condition which each solution of the equation $x^2-3x+2=0$ must satisfy. In fact, the condition is necessary, but in order to prove its necessity we must argue in a completely different way. We start with the theorem that if a product is equal to 0, then at least one of its factors is equal to 0 (a converse of the theorem that we used in the sufficiency proof). Applied to the product $(x-1)(x-2)$ this theorem shows that if this product is equal to 0, then either $x-1=0$ or $x-2=0$, i.e., either $x=1$ or $x=2$. Since $x^2-3x+2=(x-1)(x-2)$ the equation $x^2-3x+2=0$ can thus not be satisfied by any number different from 1 and 2. This completes the proof that 1 and 2 are the solutions of the equation.

Now I wish to point out a case in which the confusion of necessity and sufficiency actually leads to errors. In algebra it is shown that a quotient of two polynomials may be represented as the sum of so-called partial fractions. Let us, for instance, consider the quotient

$$\frac{x+3}{x^2-1}=\frac{x+3}{(x+1)(x-1)}.$$

Applied to this quotient the theorem states that two numbers A and B can be found such that the relation

$$(+)\qquad \frac{x+3}{x^2-1}=\frac{A}{x+1}+\frac{B}{x-1}$$

holds for each number x. One of the methods to find the numbers A and B consists in this: We first multiply both sides of the relation $(+)$ by the denominator of the left side thus getting

$$x+3=(x-1)A+(x+1)B.$$

Then one calculates the values of A and B by substituting special numbers for x.

By substituting $x=-1$ we get $-1+3=-2\cdot A+0\cdot B$,
i.e. $2=-2A$ and thus $A=1$.
By substituting $x=+1$ we get $1+3=0\cdot A+2\cdot B$,
i.e. $4=2\cdot B$ and thus $B=2$.

Consequently, it is concluded, the following formula is valid:

$$\frac{x+3}{x^2-1}=\frac{-1}{x+1}+\frac{2}{x-1}.$$

This statement happens to be right but it is not at all proved by the preceding argument. This argument merely shows that if two numbers A and B satisfy the relation $(+)$ for each x, then these two numbers A and B have the values -1 and 2, respectively. That conversely these values for A and B actually satisfy the relation $(+)$ has to be proved separately by substituting them into this relation and by proving that then the expressions on both sides are equal.

Now let us deal exactly in the same way with the quotient

$$\frac{x^2+1}{x^2-1}=\frac{x^2+1}{(x+1)(x-1)}$$

and try to find two numbers A and B such that the relation

$$(++) \qquad \frac{x^2+1}{x^2-1}=\frac{A}{x+1}+\frac{B}{x-1}$$

holds for each number x. We first multiply both sides of the relation $(++)$ by the denominator of the left side thus getting

$$x^2+1=A(x-1)+B(x+1).$$

Then we try to calculate A and B by substituting special numbers for x. By substituting -1 for x we get $2=-2A$ and thus $A=-1$. By substituting $+1$ for x we get $2=2B$ and thus $B=1$. Thus we proved in a perfectly correct way that if two numbers A and B satisfy the relation $(++)$ for each x they necessarily have the values -1 and $+1$ respectively. Yet it would be com-

pletely wrong to conclude that the relation $(++)$ actually holds for these two values. In fact, it does not. If the relation held we should have for any number x:

$$\frac{x^2+1}{x^2-1}=\frac{-1}{x+1}+\frac{1}{x-1}.$$

This is wrong, however, for if we substitute, for instance, 0 for x, the left side is -1 and the right side is -2. The solution of this apparent paradox is, of course, that there do not exist any two numbers A and B which satisfy the relation $(++)$. In fact, we proved quite correctly that if any two numbers A and B should satisfy the relation it would necessarily have to be the numbers -1 and $+1$, and then we showed that these numbers do not satisfy the relation. Consequently, no pair of numbers A and B does.

This example shows that the logical distinction between necessity and sufficiency of a condition is by no means mere hair-splitting but the only way of preserving us from serious errors.

After these examples from algebra we consider the field of geometry. The two principle methods in elementary geometry are the postulational method that came to us in Euclid's Elements and the analytic method introduced by Descartes.

Analytic geometry of the plane makes pairs of numbers (coordinates) correspond to the points of the plane and describes each straight line by a linear equation in two unknowns. Finding the point of intersection of two straight lines means finding the common solution of two linear equations in two unknowns. All mistakes that can be made in algebra with regard to systems of linear equations may thus be translated into errors in analytic geometry.

We saw how one usually proves that if x is a solution of the equation $3x+2=0$, then $x=-2/3$—and erroneously takes this as a proof for the fact that $x=-2/3$ is a solution. The corresponding error in analytic geometry can be made by considering the two straight lines given by the equations $y=3x+2$ and $y=0$, and by trying to find their common point. The usual argument shows that if a point lies on both lines, then it has the abscissa $-2/3$. In other words, what is usually derived is a necessary condition for the abscissa of the point of intersection. It would be wrong to conclude from this argument that a point with the abscissa $-2/3$ actually lies on both lines, or, in other

words, that the condition is sufficient. It happens to be, but one has to prove separately that this is the case.

We saw how one can correctly prove that if x is a solution of the equation $3x+2=0$ then x is necessarily either $2/3$ or $-2/3$. But only the second of these conditions is sufficient. This argument can be translated into the following reasoning in analytic geometry. One can correctly prove that if the straight lines given by the equations

$$y=3x+2$$

$$y=0$$

have a point in common then it is either a point with the abscissa $x=2/3$ or a point with the abscissa $x=-2/3$. But only a point with the second of these abscissas does actually lie on both lines.

In order to find the point in common to the lines $y=x+1$ and $y=-x-1$ we argue in the following way: If a point with the abscissa x lies on both lines, then its ordinate has to be both $=x+1$ and $=-x-1$. Consequently, the number x satisfies the equation $x+1=-x-1$ and is thus $=-1$. Conversely one easily verifies that the point with the abscissa -1 and the ordinate 0 actually is common to both lines. It would also be quite correct to argue: If x is the abscissa of a point which lies on both lines, then $x+1=-x-1$, consequently $(x+1)^2=(-x-1)^2$. But the latter condition holds for any number x whereas only one number x is abscissa of a point that is common to the two straight lines.

Postulational geometry found a model of its rigorous treatment in Euclid's Elements. This book is, of course, free of such primitive logical mistakes as the confusion of necessity and sufficiency. It may be worthwhile to examine a particular case in which postulational geometry avoids such confusion. One of Euclid's postulates (the famous parallel postulate) states that if a line L intersects two lines L_1 and L_2 in such a way that the sum $\alpha_1+\alpha_2$ of the internal angles on one side of L is smaller than two right angles, then L_1 and L_2, if sufficiently extended on this side of L, intersect. From this and other assumptions it follows that if $\alpha_1+\alpha_2$ is greater than two right angles, then L_1 and L_2 likewise intersect. That $\alpha_1+\alpha_2$ is different from two right angles is thus a sufficient condition for the intersecting of L_1 and L_2. But, of course, this in itself does not imply that this condition is also necessary. To conclude from the above-men-

tioned statement that if L_1 and L_2 intersect, then $\alpha_1+\alpha_2$ is different from two right angles—would be just like concluding from the information that nobody will ring a certain bell tomorrow before or after 3 P.M., that somebody will ring it at 3 P.M., though obviously it would be perfectly compatible with the above-mentioned information that nobody will ring the bell at 3 P.M., thus that nobody will ring the bell tomorrow at all. The condition that $\alpha_1+\alpha_2$ is different from two right angles, happens to be also necessary for the intersection of L_1 and L_2, but its necessity has to be proved separately and is proved separately in Euclid's Elements, notably from other assumptions than the parallel postulate.

After having discussed algebraic and geometric examples I wish to mention an example taken from analysis, namely, a problem concerning the maximum and minimum values of a function.[4]

We shall consider a function $f(x)$ of one variable, defined for each value x between the two numbers a and b. In a well-known way such a function can be represented by a curve $y=f(x)$ in the xy-plane of analytic geometry. Find the greatest and smallest values of $f(x)$ means finding the peaks and pits of the curve $y=f(x)$. We shall restrict ourselves to the consideration of curves which have a tangent at each of their points, i.e., no corner or other singularities.[5]

Let us first consider an interior point of the curve, i.e., a point whose abscissa x is greater than a and smaller than b. If the tangent at the point points upward to the right, then the curve is higher to the right of the point x and lower to the left of the point x than it is at the point x. Thus at the point x there can be neither a pit nor a peak of the curve. Consequently, at a peak or pit in the interior of the curve the tangent cannot possibly point upward to the right. In a similar way we see: If the tangent at an interior point x points upward to the left, then the curve is higher to the left of the point x and lower to the right of the point x than it is at the point x. Thus at the point x there can be neither a pit nor a peak of the curve. Consequently, at a

[4] Questions of this type, though with regard to more complicated functions than we shall consider here, constitute a chapter of mathematics called the calculus of variations (see the author's paper "What is the Calculus of Variations and What are its Applications?" *The Scientific Monthly*, September 1937). It is this chapter of mathematics to which we referred at the beginning, by saying that even great mathematicians of former ages did not avoid the confusion of necessity and sufficiency.

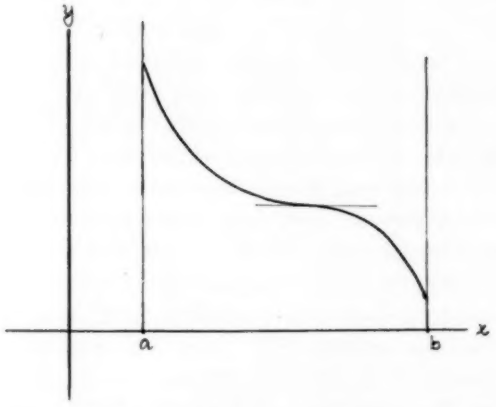
[5] It should be realized that this assumption means a considerable restriction. A curve as simple as the one given by the equation $y=+\sqrt{x^2}$ has a corner and thus no tangent at the point with the abscissa 0, and that is just the point where the curve has its pit.

peak or pit in the interior of the curve the tangent cannot point upward to the left. Since at a peak or pit in the interior of the curve the tangent cannot point upward either to the left or to the right, it follows that at a peak or a pit in the interior of the curve the tangent is necessarily horizontal. Horizontality of the tangent is thus a necessary condition for an interior point if it shall possibly be a peak or a pit.

Two mistakes must be avoided:

1) One must not overlook that this condition is necessary only for interior points. For the initial point of the curve (the point with the abscissa a) and the terminal point of the curve (the point with the abscissa b) the condition is not necessary. In fact, the curve in our figure has a peak at the initial point and a pit at the terminal point without having a horizontal tangent there.

2) One must not take the condition as sufficient even for interior points. The curve in our figure contains an interior point with a horizontal tangent without having either a peak or a pit there.



Concerning the initial point of a curve we may say that if the tangent points downward to the right, then the curve has a peak at this point, and if it points upward to the right, then the curve has a pit there. Concerning the initial point of a curve we have thus a sufficient condition for a peak (pointing downward to the right of the tangent) and a sufficient condition for a pit (pointing upward to the right of the tangent). These conditions, however, are not necessary. A curve may have a peak at the initial point though its tangent there is horizontal and thus does not point

downward to the right, and a pit at the initial point though the tangent there is horizontal and thus does not point upward to the right. Similar considerations hold for the terminal point of the curve.

In teaching the elements of calculus one frequently neglects the two end points of the curve altogether with effects that will be seen presently. Let us first consider the famous question as to which rectangle of a given perimeter p has the greatest possible area. If we call x the length of one of the sides of a rectangle with the perimeter p, then x is a number between 0 and $p/2$ and may assume any value between these two numbers, the numbers themselves being included among the possible values. The length of either of the perpendicular sides is then $p/2-x$, the area of the rectangle is $x((p/2)-x)$. The question of finding the values of x for which this area assumes its maximum value is equivalent to the problem of finding the values of x for which the function $x((p/2)-x)$ assumes its maximum, and to the problem of finding the peaks of the curve $y=x((p/2)-x)$ where x varies between 0 and $p/2$. This curve is an arc of a parabola. The only point of this arc where the tangent is horizontal is the vertex of the parabola, i.e., the point with the abscissa $p/4$. Thus if an interior point of this arc is a peak it must necessarily be the point with $x=p/4$. Conversely, one can show that for this abscissa the parabola actually has a peak. Thus $p/4$ is the length of the side of the rectangle those area surpasses that of the other rectangles with the perimeter p. The length of either of the perpendicular sides is $p/2-p/4=p/4$, thus all sides of this rectangle have the length $p/4$; in other words, the rectangle with a given perimeter and maximum area is a square.

Suppose now somebody asked which rectangle of given perimeter p has the smallest possible area. This question is equivalent to the problem of finding the minimum of the function $x((p/2)-x)$ or the pits of the curve $y=x((p/2)-x)$. By following the usual procedure, that is to say, by merely looking for those points of the curve where its tangent is horizontal we do not get any answer to this question. For, as we saw, there is only one point with a horizontal tangent in this curve, viz., the point with the abscissa $p/4$, and at this point the curve has a peak, not a pit. The incomplete procedure which we criticized above (the taking of a horizontal tangent as a necessary condition for a peak or a pit, whereas it is necessary only for interior points of the curve) leads thus to the result that there is no

rectangle with smallest area, a result which contradicts not only general theorems but also obvious facts concerning rectangles. If we take in account that the curve not only may have pits at interior points with horizontal tangents but certainly has a pit at the initial point if the tangent there points upward to the right, and at the terminal point if the tangent there points upward to the left, then we see in our case that the arc of the parabola has its pits at the initial and the terminal point, i.e., for the values 0 and $p/2$ of the abscissa. The corresponding rectangles are those in which two sides have the lengths 0 and either of the two other sides has the length $p/2$. They are degenerated flat rectangles with the area 0.

As a general rule one can say that in maximum and minimum problems we usually find some conditions that are necessary and some conditions that are sufficient, but hardly ever conditions which are both necessary and sufficient.

After having mentioned necessary conditions which are erroneously taken to be sufficient and sufficient conditions which are erroneously taken to be necessary, in conclusion I should like to mention a case where (at least in applied mathematics) a condition is taken to be necessary and sufficient though, in fact, it is neither necessary nor sufficient. In dealing with systems of several equations in several unknowns, engineers, economists and other scientists who apply mathematics, frequently take it for granted that the system of equations has one and only one solution, if and only if the number of equations is the same as the number of unknowns. However, this condition is neither necessary nor sufficient, even if we consider systems of linear equations.

In order to see that it is not sufficient let us consider the following two equation in two unknowns:

$$x+y=1$$
$$2x+2y=3.$$

Though the number of unknowns is the same as the number of equations it is clear that these equations have no common solution. If, on the other hand, we consider the two equations.

$$x+y=1$$
$$2x+2y=2$$

then we have two equations in two unknowns which have in-

finitely many solutions. It is easy to set up systems of three linear equations in three unknowns which have no solution or infinitely many solutions, though it is sometimes less easy to realize these properties by inspection of the equations.

In order to show that the condition is not necessary we consider the following three linear equations in two unknowns which have exactly one solution:

$$x+y=1$$
$$2x+3y=2$$
$$4x+4y=4.$$

While in this example the number of equations exceeds the number of unknowns, it is easy to give an example of a system in which the number of unknowns exceeds the number of equations and yet there exists exactly one solution if we restrict ourselves to the domain of real numbers, viz., one equation in two unknowns $x^2+y^2=0$.

In the case of systems of linear equations we know conditions concerning the coefficients which are both necessary and sufficient for the solubility and the uniqueness of the solution. As was mentioned above, the necessary and sufficient conditions that the linear equations

$$ax+by=m$$
$$cx+dy=n$$

have one and only one solution is that the number $ad-bc$ be different from 0. With regard to many types of systems of more complicated equations, however, we do not know conditions which are necessary and sufficient for the possibility of solving them. Certainly it is, in general, neither necessary nor sufficient that the number of equations and the number of unknowns be equal.

GASOLINE FROM COAL

England is investing nearly $30,000,000 in a new plant for the production of petroleum by the hydrogenation of coal, it has been learned by Industrial and Engineering Chemistry here from its British foreign correspondent.

The plant, the second to be built in Great Britain, is to be financed by government capital with the Imperial Chemical Industries, Ltd., the management corporation. The I. C. I. already operates the large coal-hydrogenation plant at Billingsham-on-Tee for the production of gasoline.

THE LABORATORY—PRO AND CON

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During the past few years more and more discussion on the part of educators has centered about the value of a high school science laboratory. There have been many instances in which the laboratory and its educational values have been attacked. Many administrators have questioned the additional expense involved. There are those in the field of educational research who believe that pupils learn as much without the laboratory as they do with it. Any complete list of comments for and against the laboratory would be long and perusal of such a list would be rather exhausting. Suffice it to say there has recently accumulated a greater mass of argument against the value of this teaching aid than in its favor.

We must begin any examination of such a question with an examination of ourselves. What are we trying to do *to* the child in our attempts to educate him, and what methods will do this best? In other words, let us define our aims, because only in the light of such definition can we arrive at any conclusion as to procedure which will enable us to reach our objective.

No doubt, in the large and diverse educational system of this country there are still many teachers who believe the primary object of their work to be the teaching of factual information. The students are parrots, to be taught as such; information is handed out and at a later date, either oral or written, this information is handed back. The amount of "education for life" which has taken place during the process is of little consequence. The important thing is that a student has been told that hydrogen is the lightest known substance, and at a later date is able to tell the teacher that hydrogen is the lightest known substance. In the meantime no attitudes whatever have come to the student regarding the industrial value of hydrogen or why it may become an implement of war.

Also, in our diverse educational system are many people who believe that student accomplishment and capability may be measured by means of a statistical yardstick. All that is necessary to decide whether a student may or may not become president is to determine his I.Q. There are administrators who measure the ability of a teacher in terms of marks made by his or

her pupils on examinations sent out from the superintendent's office. One school teaches chemistry by means of the lecture demonstration method and another school uses the lecture laboratory method in which students work their own experiments. When the lecture demonstration class makes marks on examinations which are as good as those made by pupils who work in the laboratory, it is concluded the laboratory is of little value and consequently can be eliminated.

Before continuing with this phase of our discussion, let us return to some fundamental questions in the business of education. Is it more important to teach a child chemistry, history, or English than it is to teach him the value and importance of tolerance? Is it more important to teach the mathematics of physics than it is to teach the value of courtesy; honesty, to stress the importance of being able to see things from the other fellow's viewpoint? Just what do we expect this boy or girl to be when he becomes a man or woman, a research scientist or a good citizen? Isn't it all-important that we develop their ability to think for themselves? Is there not a crying need for more people who have these characteristics? Are not our chief aims in education the development of character; attitudes which these people should have toward life, and the ability to meet life situations through clear, straight, logical reasoning?

Let us consider some of the reasons for the elimination of laboratory work in high school sciences. Here again, as part of our broad attempts to reach objectives already outlined, it is necessary to question ourselves concerning just what we desire most in each of our pupils. It is this writer's opinion that one of the most important goals toward which we must direct those we teach, is the ability to think for themselves in a straight line toward a logical conclusion.

The high school laboratory does offer problems in the setting up of the educational program. It does create difficulties in the programming of classes during the school day. It is easier to fit a one period per day subject into the curriculum than it is to fit a subject in which pupils meet one period one day and two periods on the next. No doubt it is cheaper to teach a high school science without laboratory work than it is to teach with it. An instructor working in a school in which 30 periods is considered the weekly teaching load cannot teach as many students and as many classes if his subject meets 7 periods a week as he could if the subject met but 5 periods per week. It

is also argued that many pupils go through the routine of a laboratory experiment in a mechanical fashion, and, having finished the experiment, know little more about it than they did when they started. And again, although it has previously been mentioned, we should consider the argument that pupils test the same whether they have been taught by means of lecture demonstrations or whether they have been doing their own laboratory work.

Having defined some of the factors which have resulted in the elimination of laboratory work in high school science classes, and being unwilling to allow such arguments to go unanswered it may be well to reconsider them. Upon curricular problems which arise from laboratory double periods, the writer pretends to be no authority. There is no doubt that difficulties are involved in placing the two period sections into the school day. Considering the variety of subjects which are now offered the high school student, it may be impossible to prevent such program difficulties. However, due to the fact that conflicts between laboratory sections and other subjects do arise, this part of the science class suffers to a definite extent. As the usual high school laboratory is set up, the pupils meet for two consecutive periods on each of two days per week. When this laboratory period requires a pupil to set up equipment which may require 10 to 15 minutes it is a distinct advantage for him to have a long uninterrupted amount of time for the work. When conflicts arise, which result in a student taking one period of his laboratory in the morning and the other period that afternoon or the next day; or the placing of second semester pupils in first semester laboratory sections, or vice versa, teachers are unable to systematize their work as well; the amount of consecutive work accomplished is definitely decreased; and it is unfair to the student. If a science is to be taught properly and a laboratory is deemed necessary to the proper teaching of the subject, then everything possible should be done to enable the student to derive maximum benefit in his laboratory as well as his lecture time. By way of emphasis regarding the importance of keeping student laboratory periods consecutive rather than splitting them might be mentioned a number of instances in which almost one-third of the student laboratory time has been wasted because he had to set up and take down apparatus twice rather than once. This was the result of what might be termed a split period.

One of the most potent arguments for elimination of laboratory work in high school sciences has been the resultant saving in cost. In order to decide whether a saving is being made or not, it is necessary to define the type of economy desired. If we are thinking strictly of dollars and cents needed to operate a school then there is no doubt but that the elimination of laboratory work accomplishes that end. As has been previously mentioned, a given teacher can handle more classes and teach more pupils if the science consists of one period per day classes or the so-called lecture demonstration method. If we are interested primarily in saving money with little regard to what that saving does to the achievement of a student then laboratory work as such can be definitely curtailed.

The business of education should not be operated in any manner other than that in which desired results may be best accomplished. We all realize the necessity of keeping within an educational budget and realize, too, that many savings which are necessary, are obtained at some cost to the student. If we presume that laboratory work shall be dropped because those students who have had this work do not surpass, in factual information those who have not had it, then I disagree with any such elimination. I am yet to be convinced that there has been set up any accurate and complete method of testing some rather intangible assets which a student develops in laboratory work. Conclusions regarding any such study as this must consider capabilities of various teachers in the subject. The good teacher in chemistry can develop in his or her students, a very definite ability to not only think for themselves, but to apply information. These pupils have the opportunity of developing a manual technique in the assembly of apparatus for various experiments throughout the year. To those students who are going on to college and who will enroll in more science at that time, this laboratory experience is not only valuable but is essential. Imagine, a student in chemistry who has been taught by the lecture demonstration method being rather suddenly tossed into a college chemistry laboratory which meets from 3 to 6 hours per week. I wonder how much ability in handling scientific equipment the student has gained by sitting in a lecture class and watching his instructor run experiments. Is it fair to deny such students the opportunity of preparing themselves for college laboratory work? There are, then, two ways of saving money—an immediate saving in which all students are denied

the privilege of the laboratory, and a saving which will come to that student later on as a result of having had the opportunity to develop laboratory technique. Which of these is most desirable?

I do not maintain that all students must do laboratory work as a part of their science course. I do believe, that all students enrolling in such courses should have the opportunity of laboratory work until it has been definitely proved that some do not benefit from it. The method by means of which all students are given an opportunity to do experimental work and a consequent elimination of those who cannot has been previously discussed by the writer.*

Another criticism which has been made of laboratory work in high school science is that students do experiments mechanically. They read directions, and go through the motions, so to speak, but learn little as a result of the time spent. This fact is true. There are students in every class who behave in just that way. As such pupils are discovered, they should become candidates for a lecture demonstration class; they should not serve as a penalty for all students enrolled in the subject. In other words, why penalize many for the inability and ignorance of a few? Such a criticism of laboratory work is no more valid than to argue that a student should be dropped from Latin or English or any other subject simply because he seems to be making no progress. Just what difference is there between a pupil who fails to respond in the laboratory and one who fails in any other subject? It is a rather fine line of demarcation. Won't the student who is making the most of his opportunities in school do good work in the laboratory as well as in all his studies? Won't the pupil to whom school is a bore, and a waste of time, do poor work regardless of the subject in which he is enrolled? Where then, is the basis for such criticism of a high school science laboratory?

Finally we come to a criticism of the laboratory which has gained much publicity. It has been found in many instances that pupils taught by the lecture demonstration method make marks on tests which are as good as those made by students who have spent part of their time in the laboratory. The fact that this is regarded as important by any school official is an

* "An Experiment in the Teaching of High School Chemistry," SCHOOL SCIENCE AND MATHEMATICS, November, 1937.

admission that the primary function of his school system is the dispensation of facts. If this creation of intellectual parrots is to be the most important function of the teacher and the school, then let us test, and thus estimate the ability of our teachers, and the achievement of our educational system.

Valedictorians of high school graduating classes are not always characterized by an ability to reason which is commensurate with their scholastic average. A student who has absorbed many facts during his high school career, but is unable to correlate and apply such information to life problems later on, is not the kind of educated person we are trying to produce. The student who may not stand quite so high in his class but who has developed an ability to think clearly in a straight line toward a logical conclusion has a much greater chance of success. A student in a laboratory science who refuses to take advantage of the opportunities afforded him to develop his ability to think for himself is a very foolish person. That such opportunities are present in any well-conducted laboratory is common knowledge.

It would be rather unfair to present and future students for us to draw conclusions without giving such people an opportunity to present their side of the story. With this in mind, a questionnaire summarizing student reactions with regard to the value of the laboratory was given to 51 people, scattered throughout four different classes. A copy of the questionnaire follows.

Student Reactions to the Value of Laboratory.

1. Would you favor eliminating the laboratory as a part of the chemistry course?
2. Do you think you have gained information as a result of your laboratory work which you would not have received had you not had this laboratory work?
3. What are your chief criticisms of our laboratory as it is now?
4. Would you like to spend more or less time in laboratory work?
5. List your best reasons for continuing and improving our laboratory work.
6. Are you planning to attend college?
7. Will your college work require this year of chemistry?
8. Why did you elect this year of chemistry?
9. Did the fact that we spend much time in the laboratory help you to decide in favor of chemistry?
10. Generally speaking, would you be in favor of increasing the amount of time spent in laboratory work in all the high school sciences?
11. What would be your chief criticism of our science laboratories as they exist at present, with particular reference to amount of time spent in laboratory work?

The reactions to the questions were as follows: (1) No—49, Yes—1. (2) Yes—45, No—1. (3) The outstanding criticism which appeared in the great majority of papers was "Insufficient equipment." (4) More—34, Same—12, Less—4. (5) The following were the reasons and suggestions which appeared most often: (a) Makes chemistry real. (b) Teaches exactness and accuracy. (c) You have a chance to work things out for yourself. (d) You will remember better if you do it yourself. (e) You have the opportunity of doing your own thinking. (f) "Experience is the best teacher." (6) Yes—37, No—5. The rest were uncertain. (7) Yes—36, No—5. (8) The answer here fell into one of two classifications: (a) they like science and (b) they needed the chemistry for future work in college or as preparation for nursing, etc. (9) Yes—34, No—9. (10) Increase—28, No increase—23. (11) Appearing upon paper after paper the answer to No. 11 was a recommendation that specific laboratory time and work be included in our course in Biology. It is my conviction that students are given insufficient opportunity to take part in deciding such questions as this. Recognizing the fact that they are young and immature, I also recognize the fact that the laboratory or lack of laboratory affects them more than it does myself. If they feel there is a need for such work which they may do themselves and that they derive a definite benefit from it, certainly this should be considered in any decision which might be made upon the subject.

Several points in the results of this questionnaire should be emphasized. First, pupils are overwhelmingly against elimination of laboratory work. Second, 90% of them say that laboratory work has given them information they would not have received, or would not have received in the same way, in a lecture class. Third, they bitterly criticized our lack of apparatus with which to work. Fourth, almost 70% of them would favor even more time devoted to laboratory work than is given to it at present. Fifth, notice the reasons for continuing and improving laboratory work: (a) teaches exactness and accuracy; (b) you'll remember it better if you do it yourself; (c) you have a chance to do your own thinking. Are not these some of the most important goals for which a teacher should strive? Sixth, an astonishing number of these pupils, 74% of them to be exact, say they are going to college, and 98% of these say that chemistry will be needed in the college work. Seventh, over 65% or 2 out of 3 say that the opportunity of spending time in

the laboratory influenced them in electing chemistry. They are very emphatic about the need for laboratory work in biology and condemn the use of what they term a very good laboratory purely as a classroom.

Laboratory does teach a student to be accurate and exact. It teaches the value of persistence. It teaches students to depend upon themselves rather than their neighbor. It develops the ability of a student to think clearly and logically. It teaches cleanliness, for without cleanliness most laboratory reactions are a failure. It teaches consideration of others. Upon many occasions students in a laboratory have criticized certain of their fellow students for talking loudly; borrowing equipment without asking for it; or asking for the answer to a question. The laboratory offers a pupil the opportunity of developing manual technique in the assembly of apparatus. Such technique cannot be acquired by watching someone else run an experiment. Such technique is essential to the achievement of these students in college chemistry. Finally, the fact that students spend a given portion of their time in running their own laboratory experiments, increases to a surprising degree the interest of the student in the subject. Few, if any, teachers will deny that a very close correlation exists between the interest a pupil has in a subject and his achievement in that subject.

INVISIBLE INDIAN VILLAGES

Invisible Indian villages, marked only by tiniest surface clues, have been detected in mountains of western New Mexico by Field Museum of Natural History's expedition in search of the little-known Mogollon Indian culture of the old Southwest.

The dead and buried villages were found just off the trail followed by the Spanish gold-hunting expedition of Coronado, which marked that way in its futile search for the fabulous wealth of the "Seven Cities of Cibola," says the first report of the find, received here from the expedition leader, Dr. Paul S. Martin.

Thumbnail-size scraps of brown Indian pottery, scarcely different from pebbles in appearance, drew the archaeologists' attention to the significance of the site. Excavating, they have uncovered walls and floor of a subterranean pithouse used by Indians for celebrations. The underground building is 33 feet in diameter, and is pronounced one of the largest structures of the kind ever excavated in the region.

Like gold-hunting Coronado, modern local pottery hunters have never suspected the presence of the hidden prehistoric settlements. The place had already been abandoned more than 700 years when Coronado passed by, in the 1540s, according to Dr. Martin's estimate of the site's antiquity.

The expedition, he reports, has already found important clues concerning the age and development of the Mogollon culture of the Southwest.

TESTING THE CLARITY OF MATHEMATICAL CONCEPTS

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The phenomenon of "verbalism" or "lip service" is a common place occurrence in the classroom, as every experienced teacher knows full well. Indeed, it extends beyond the mathematics classroom, and appears to be pretty generally a part of the outcome of instruction in most of the so-called academic subjects. As the term is used here, *verbalism* refers to the use of words or phrases whose meaning has apparently been mastered, although actually the concept in question is only vaguely grasped or ill-understood. Not infrequently the pupils who use these terms glibly and smoothly do not have the slightest notion of their meaning.

The clarification of perceptual imagery, the integration of associations, the progressive improvement of understanding, the increased lucidity of ideas, and the eventual achievement of adequate insight and conceptualization, particularly with respect to the more highly abstract notions and generalized concepts,—all these present a double problem in teaching. On the one hand, these goals are intrinsically difficult of attainment, and on the other, they do not readily admit of detection or appraisal. While this situation may be understandable in the case of the physical and the social sciences, it is somewhat less excusable in the case of mathematics, where the objective nature of the subject matter would seemingly simplify matters.

In the present paper no attempt will be made to deal with the first problem. We are here concerned with the possibilities of revealing and evaluating the degree to which pupil-mastery of conceptualization has been realized as an outcome of instruction. To be sure, every teacher can and should form an opinion concerning this mastery in an informal, approximate way concomitantly with the learning-teaching process, i.e., through oral discussions, during recitations, by questions and answers, by inferences, etc. At the same time, it would appear that many teachers unconsciously assume that when a pupil uses a term more or less accurately or appropriately, he thereby automatically gives evidence of a genuine understanding of that term. No mistake is easier to make than this.

It is our purpose to present (1) a list of reasonably important and commonly encountered mathematical terms, most of which are verbal symbols for fairly abstract or generalized concepts, and (2) a suggested short-answer type test including some of these terms, the aim of which is to reveal to the teacher the degree of mastery of those terms, or at least, which ones are inadequately understood. It should be said at once that this list of terms is by no means complete, and that it represents, frankly, an arbitrary choice. The selection was guided, however, by a review of the literature of the subject. It should also be pointed out that since the proposed test has not been used with pupils there is as yet no criterion as to its validity; and that to be of any value at all, it must be used only under carefully controlled experimental conditions. Even then, it may prove of slight value. Neither can any indication of the reliability of the test be given at this time. Yet, despite these limitations, it is offered in the spirit of a constructive suggestion to "get at" something which we need very much to know, and concerning which little has as yet been done. If it proves a stimulus for further study, our object shall have been accomplished.

List of Mathematical Concepts

1. acceleration
2. accurate
3. analogous
4. approximate
5. arbitrary
6. assumption
7. average
8. axiom
9. axis
10. coefficient
11. coincide
12. component
13. congruent
14. constant
15. continuous
16. converge
17. converse
18. convex
19. coordinate
20. corollary
21. deductive
22. dependence
23. determine
24. deviation
25. dimension
26. discrete
27. divergent
28. eliminate
29. empirical
30. equivalent
31. error
32. estimate
33. exponent
34. extrapolate
35. function
36. gradient
37. homologous
38. hypothesis
39. identical
40. increment
41. inconsistent
42. indeterminate
43. inductive
44. infinite
45. initial
46. instantaneous
47. intercept
48. interpolate
49. interval
50. inverse
51. limit
52. locus

53. maximum
54. median
55. normal
56. notation
57. order
58. origin
59. periodic
60. potential
61. precision
62. projection
63. proportion
64. proposition
65. random
66. rank
67. rate
68. ratio
69. reciprocal
70. reflex
71. relationship
72. revolve
73. rigorous
74. rotate
75. scale
76. segment
77. sequence
78. series
79. simultaneous
80. slope
81. speed
82. successive
83. symmetry
84. systematic
85. tabulate
86. terminal
87. transpose
88. transverse
89. trend
90. unique
91. uniform
92. unit
93. variable
94. velocity

Test of Mastery of Mathematical Concepts

Directions: In each of the following statements, *one* of the several choices is the correct or best possible answer. Indicate, by number, the answer you think fits the mathematical meaning of the word most accurately.

1. An *average* suggests something (1) approximate (2) mediocre (3) exceptional (4) outstanding (5) typical
2. *Slope* refers to (1) height (2) summit (3) length (4) peak (5) inclination (6) bottom
3. *Maximum* value refers to (1) the total value (2) the average value (3) the largest value (4) an approximate value (5) the least value
4. *Simultaneous* means: (1) corresponding (2) together (3) similar (4) homologous (5) instantaneous (6) analogous
5. An *assumption* is (1) necessarily true (2) easily proved (3) very obobvious (4) quite simple (5) something agreed upon (6) indisputable
6. "Thirty miles per hour northward" describes a moving object's (1) speed (2) direction (3) velocity (4) distance (5) time
7. When two figures *coincide* they (1) overlap (2) have the same shape (3) have the same size (4) fit perfectly (5) must both be triangles
8. The *converse* of the statement "If P is true, then Q is true" is:
   (1) If P is not true, then Q is not true
   (2) If Q is true, then P is true
   (3) If Q is not true, then P is not true
9. A *trend* indicates (1) a general direction (2) a goal (3) the current vogue (4) a trial and error process (5) a method
10. *Successive* means (1) adjacent (2) increasing (3) opposite (4) one after another (5) satisfactory
11. An *axis* is usually (1) straight (2) vertical (3) parallel (4) short (5) horizontal (6) curved
12. A *convex* surface (1) curves inward (2) has hollows (3) bulges out (4) has ripples (5) is flat (6) is rough
13. A result is *accurate* because it is (1) valid (2) precise (3) authentic (4) carefully arrived at (5) backed by authority (6) derived from a reliable source

14. *An hypothesis* is essentially (1) a fact (2) a demonstration (3) an inference (4) a supposition (5) a conclusion (6) a solution
15. *Periodic* means (1) coming to an end (2) in a circular direction (3) a gradual change (4) a regular recurrence (5) frequently interrupted
16. An *increment* usually refers to (1) an excess (2) a sum (3) a surplus (4) an increase (5) a decrease (6) a deficiency
17. *Congruence* is proved by (1) coincidence (2) equivalence (3) similarity (4) equality (5) symmetry
18. *Error* has to do with (1) mistake (2) oversight (3) omission (4) approximation (5) carelessness (6) negligence
19. *Intercept* means (1) to cross (2) to include between (3) to traverse (4) to intersect (5) to cut
20. An *approximate* value is one that is (1) incorrect (2) exact (3) close to the actual value (4) better than the actual value (5) a wild guess
21. A *symbol* always involves (1) mystery (2) something unknown (3) a formula (4) an abbreviation (5) letters (6) complexity
22. A *proposition* always involves (1) an invitation (2) a debatable issue (3) specific conditions (4) definitions (5) suggestions
23. *Transpose* generally means (1) to lift up (2) to deposit (3) to solve for the unknown (4) to move across (5) to change a sign (6) to balance an equation
24. *Relationship* suggests: (1) cause (2) similarity (3) existing together (4) effect (5) equality
25. *Divergent* suggests: (1) decreasing (2) spreading (3) going away from (4) wandering (5) parallel
26. An *arbitrary* value or position means that it is (1) compulsory (2) unreal or unnatural (3) selected at random (4) artificial (5) insignificant
27. A "*constant*" is a quantity whose value is (1) always known (2) always positive (3) equal to zero (4) the root of an equation (5) the answer to a problem (6) the same throughout a given problem or discussion
28. To *eliminate* means (1) to cancel (2) to guess (3) to divide (4) to subtract (5) to prevent (6) to remove (7) to contradict
29. For two quantities to be *equivalent* it is necessary for them to be (1) equal (2) identical (3) interchangeable (4) similar (5) proportional (6) almost equal
30. *Acceleration* refers to (1) rapid change (2) skipping (3) a spurt (4) high speed (5) increase in speed (6) great velocity
31. *Coördinates* suggest (1) equal values (2) simultaneous values (3) arbitrary values (4) constant values (5) roots of an equation
32. *Order* of arrangement necessarily requires (1) equal intervals (2) haphazard selection (3) increasing magnitude (4) some definite plan (5) simplicity (6) uniformity
33. A *terminal* position may be (1) near the middle (2) near the end (3) exactly midway (4) at the very end (5) anywhere at all
34. A *continuous* curve means (1) a straight line (2) a wavy curve (3) a long curve (4) a closed curve (5) a curve with no gaps or abrupt changes
35. An *axiom* is a statement that (1) has been mutually agreed upon (2) is obviously true (3) is simply common sense (4) everybody believes (5) is true under all conditions
36. *Random* selection involves (1) willful choice (2) trusting to luck (3) deliberate preference (4) unbiased sampling (5) a few choice samples
37. A *variable* is a quantity with (1) uncertain values (2) increasing values (3) many values (4) a constant value (5) a maximum value
38. *Reflex* suggests (1) rigidity (2) flexibility (3) curving (4) turning (5) bending back (6) imagery

39. A *corollary* to a theorem is (1) the converse of the theorem (2) its opposite (3) a special case or obvious application (4) a short cut (5) a condensed proof of the theorem
40. To *estimate* means (1) to guess with some care and reasoning (2) to compute accurately (3) to guess blindly (4) to have a hunch (5) to make a stab at something
41. *Empirical* data mean figures which are (1) arbitrary (2) shrewd guesses (3) based on experience (4) artificial (5) theoretical
42. *Rigorous* thinking refers to thinking that is (1) difficult (2) logical (3) elaborate (4) complicated (5) emotional (6) careless
43. *Normal* conditions are (1) ideal (2) standardized (3) those usually found (4) perfect (5) correct
44. *Unique* values are those which are (1) rather unusual (2) absolutely fixed or determined (3) outstanding (4) coincident (5) exceptional
45. *Median* is most closely related to (1) middle (2) altitude (3) compromise (4) normal (5) average (6) mediocre
46. An *infinite* collection of things is (1) enormously large (2) inexhaustible (3) inconceivable (4) boundless (5) indescribable
47. A *gradient* suggests (1) a mark (2) a height (3) a difference in level (4) a subdivision (5) an overlapping
48. When we say a value or a point is *determined* we mean (1) that no further choice is possible (2) it was predestined (3) it may vary some more (4) it is possible to choose it as we wish (5) it was selected at random
49. A *limit* usually suggests (1) a very large quantity (2) a quantity that may be reached (3) a changing quantity (4) a quantity that may be approached (5) a very small quantity
60. *Projection* is most nearly suggested by the word (1) within (2) beyond (3) behind (4) between (5) without (6) next

In conclusion it should be pointed out that, psychologically, a word is a device for thinking about a meaning or concept; yet the more abstract the term becomes, the greater becomes the possibility of *not* thinking about the meaning which it stands for. Therein lies both the value of such terms as well as the risk attendant upon their use. The danger arises from the fact that, as a symbol, an abstract term removes the necessity for attention to its meaning, which may well become lost in the shuffle. And this is precisely what happens when, in our classroom techniques, we put a premium upon external verbal responses, stylized recitations, and oral agility. The inevitable result is mechanical manipulation, verbal memorizing, and half-baked understanding—outcomes nowhere listed in our objectives.

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DISPLAYING MUSEUM SPECIMENS

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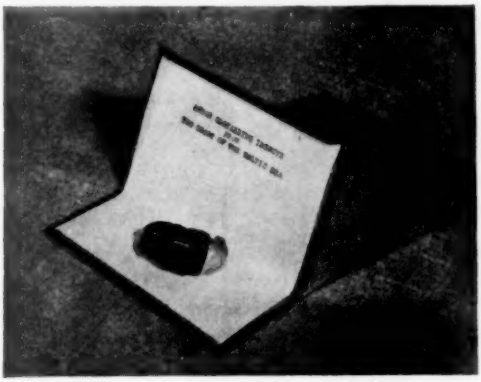
Most specimens of rocks, minerals and similar material are intended in most high schools for teaching purposes and yet they ought to be properly labeled and displayed. To do this however, in an ordinary classroom supplied only with cases with shelves set along the room walls, presents quite a problem. Where there is plenty of floor space and where the standard type of museum case is available, the difficulties are much reduced and yet even under such circumstances, the specimens are not as readily available as they would be if placed in the room where the actual teaching is done.

The label holder with specimen tray attached shown in the accompanying cut goes a long way towards solving the problem. Any tinsmith can make the holders out of any available material and have them of any shape and size. The one shown here is made of charcoal tin and will not rust but they can be enameled in any color or otherwise decorated. The label space on the one shown is 5×3 in., the tray 5×2 in. The dimensions can of course be varied to suit the type of specimen to be displayed. The label paper in this tray is light straw color.

The advantages of this type of tray are readily evident: (1) the specimen is held rather than being laid losely on a shelf; (2) the label is permanently attached; (3) the whole tray with label and specimen can be easily picked up and set out for class use or even passed along; (4) much more information can be placed on the label than is ordinarily the case; (5) they may be made in any suitable size; (6) they are inexpensive.



LABEL HOLDER WITH SPECIMEN TRAY ATTACHED

The accompanying cut shows the wording on the label, with a specimen of amber containing an embedded insect lying in the tray. A row of these trays sitting close up end to end on a shelf makes a very beautiful and impressive display.

A SIMPLE NITROGEN FIXATION APPARATUS

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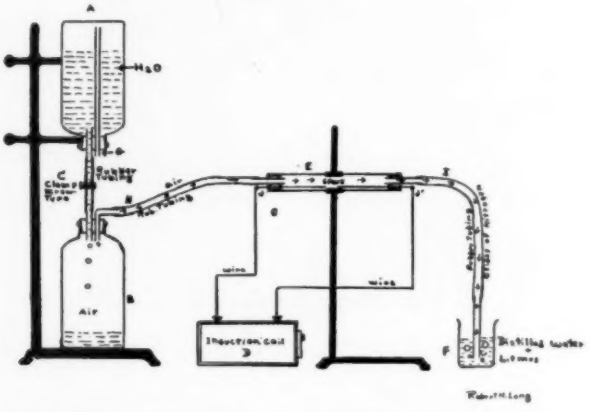
The principle of nitrogen fixation from the atmosphere supply can be easily and quickly demonstrated to chemistry and science students by means of the following demonstration apparatus. Although nitrogen oxides are not common sources of nitrate supplies, the demonstration can be used effectively to show the basic principle of the formation of nitrogen compounds in the presence of an electric spark. The substance of the procedure is the passing of air through a tube excited by an electric

spark with the subsequent formation of nitrogen oxides that when passed through water, containing an acid indicator to show change, react to form acids.

The spark chamber is made (E) by fitting a section of glass tubing (12 cm. $\times$ 2 cm. or any handy size) with one-holed rubber stoppers containing smaller glass tubing. The stoppers are punched with a nail so that a wire can be pushed through each to form the spark gap (J–J'). The power is supplied by means of an induction coil. The electrodes (J–J') should be adjusted



A Simple Apparatus for Fixation of Nitrogen

so as to produce the hottest possible spark. One end of the chamber is connected with the delivery tube (I) so that the gases can pass through the distilled water in the beaker (F). Litmus or bromthymol blue can be used in the beaker to indicate the formation of acids. A second beaker of indicator can be placed beside the one receiving the gases to show the difference in colors.

A continuous supply of slowly moving air can be fed to the chamber by the section of apparatus on the large stand. A large bottle of air is fitted with a two-holed stopper and connected with the chamber by a rubber tube (H). A second large bottle is also fitted with a two-holed stopper (A) containing a section of glass tubing to admit air at the top (G) when the bottle is inverted. This bottle is connected with A by a rubber tube having an adjustable clamp on it. By allowing the water to drop rather fast into the lower bottle a flow of air can be forced through the chamber.

HOW TO STUDY A TECHNICAL SUBJECT

LESTER DAWSON
University of Alaska, College, Alaska

At the beginning of each semester, I make the following remarks to each of my freshman mathematics classes concerning how to study. Perhaps some of the suggestions are worth emphasizing in an open letter addressed primarily to students.

To the student:

If you have been having trouble with your mathematics, physics, chemistry, or some other technical subject, you may find the following suggestions helpful in studying more effectively. (At least give them a trial.)

1. Schedule your time.

Establish regular study habits. To master any technical subject where one day's work depends somewhat upon the preceding day's work, one must study regularly. Regular habits of study will make you more consistent and accurate and will save you time. In establishing a schedule of study, start studying a particular subject on schedule and permit no exceptions to occur.

Effective study is associated with good care of your body. Proper food, sufficient sleep and regular exercise are important to good mental work. On your time schedule allow time for sleep and exercise.

2. Learn to concentrate.

Before starting to study, make conditions as favorable as possible for concentrated study by overcoming distractions. As you study, try hard to understand each idea as you read a lesson. Since successful studying of a technical subject involves not only the acquiring of knowledge, but is followed by the process of constructive study, pencil out problem examples. Keep your mind alert on the subject. Read carefully, linking the new ideas with the old.

3. Learn to reason.

Try hard to develop your power to reason by knowing the facts and associating these facts in problem solving. The student who uses reasoning in acquiring knowledge should find a delight in study.

Do not give up easily when solving problems. If a problem "stumps" you, give time to something else for a while, then come back to it later. Meanwhile you think about it subconsciously and may be able to solve it, upon returning your full attention to the problem.

4. Do not count so much on others.

Even though studying with a friend is good at times, don't expect to get a command of the lesson by copying your friend's work. Moreover, don't expect your instructor to do your studying for you.

5. Study with the idea of retaining.

Ideas are retained by repetition and expression of those ideas. In regard to your technical subject, express yourself by recitations in class, by blackboard work, by explaining to others and by writing quizzes.

6. *Develop interest* in your studies by securing extra information about them.

Talk informally with your instructor about the course. You can learn to like any subject which you have learned to understand.

7. Think of examinations as an inventory of your knowledge of the course.

Tests are an incentive to work hard. Properly constructed examinations should link up facts in new ways. In technical subjects, last minute *cramming cannot replace* regular *conscientious work*.

Get good sleep on the night before an examination and don't over-eat beforehand.

Upon entering the examination room glance over the whole test to see what is expected of you. Then carefully read each question before you answer it. While taking the examination, if it seems too long, proportion your time so as to cover the entire examination as nearly as possible.

In the case of quizzes or tests, after your paper has been returned to you, rework any problems that you missed. Avoid making the same mistakes again. A man who had stumbled over a foot-stool in a dark room would be called crazy if he stumbled over the same obstacle each time he entered the dark room, wouldn't he? Do not repeat mistakes over and over again.

To summarize, *effective study should be enjoyable, concentrated, independent study done* on a *regular schedule* with the idea of *retaining facts* and *developing reasoning ability.*

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Books:

1. Kitson, H. D., "How to Use your Mind," Lippincott & Co. (1921 edition), Philadelphia.
2. Headley, L. A., "How to Study in College," Henry Holt & Co. (1926 edition), New York.
3. McMurry, F. M., "How to Study," Houghton Mifflin & Co. (1909 edition), Boston.

A NOTE REGARDING LECTURE ROOM STOP WATCH

EDW. B. COOPER, *Brookline High School, Brookline, Mass.*

The Warren Telechron Company of Warren, Mass. will supply on special order a synchronous motor and gear drive which gives a shaft rotation at the rate of once in ten seconds or, as is stamped on the motor plate, at 6 R. P. M. These motors are self starting and stop very quickly after the current is shut off. A stopwatch with a dial eight inches in diameter was built and tested by comparison with a Cenco Impulse Counter which counts at the rate of 120 cycles per second and it was found that by adding a little friction (a rubber stopper on the shaft, rubbing against the motor frame) the two kept in exact step. The price of the motor is about $5.50.

ASCORBIC ACID (VITAMIN C)

DR. E. NEIGE TODHUNTER, *Washington State College*

Fruits and vegetables are the only significant sources of ascorbic acid in the diet. Some of these are much richer sources than others and their content may be influenced by differences in variety, soil conditions, methods of storage and handling.

Ascorbic acid's functioning within the body is still far from completely understood. But it is essential for normal development of bones and teeth; for cell respiration; for maintaining the structure of blood vessel walls.

Prospective mothers and those nursing children have an increased need for ascorbic acid. An infant is born with some store of ascorbic acid in the liver, but this is rapidly depleted. Artificially fed infants should be given fruit juice or some other source of ascorbic acid at an early age.

Pure crystalline ascorbic acid is useful in some clinical cases, where patients cannot use natural foods, or who need very high dosages. The body, however, appears better able to utilize vitamin C in the natural form in which it appears in foods. Also, these foods provide other vitamins and minerals.

Oxygen of the air, especially when heated, can destroy ascorbic acid. It is also soluble in water. That makes it important to cook fruits and vegetables properly to retain this essential dietary factor.

Newer methods of measurement of ascorbic acid indicate that the average person requires at least 50 to 60 milligrams of this vitamin daily.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-second Meeting

MARINE BIOLOGICAL LABORATORY
Woods Hole, Mass.

Saturday, May 13, 1939

PROGRAM

10:15 Meeting of the Executive Committee.
10:30 Report of the Secretary.
Report of the Treasurer.
Report of the Nominating Committee.
10:45 Talk: Dr. Samuel E. Pond, "The Marine Biological Laboratory."
Visit to the Marine Biological Laboratory, the U. S. Bureau of Fisheries, the Woods Hole Oceanographic Institution, and the Atlantis, as far as is possible in the time available.
1:00 Luncheon.
2:00 Address: Dr. Peter V. Karpovich, "The Physics and Chemistry of Swimming."
3:00 Address: Professor J. W. M. Bunker, "Biological Engineering."

BUSINESS MEETING

Mr. James H. Ritter, Providence, R. I. and Mr. John C. Simkevich, Classical High School, Providence, R. I. were elected active members.

The present membership of the association is 130 active, 38 associate, and 2 honorary members, making a total of 170.

A vote of thanks to Dr. Pond and Mr. Ballard for their hospitality and for all they did in arranging for the meeting at Woods Hole, was taken.

REPORT OF THE NOMINATING COMMITTEE FOR 1939–1940

President: Robert W. Perry, Malden High School, Malden, Mass.
Vice-president: Thomas A. Pickett, Roslindale High School, Roslindale, Mass.
Secretary: Carl W. Staples, Chelsea High School, Chelsea, Mass.
Treasurer: Preston W. Smith, 208 Harvard St., Dorchester, Mass.
Executive Committee:
Lawrence A. Howard, East Boston High School, East Boston, Mass.
Everett J. Ford, English High School, Boston, Mass.
Winthrop S. Drury, Middlesex School, Concord, Mass.

Respectfully submitted,
BURTON L. CUSHING, *Chairman*
WILLIAM W. OBEAR

The above named were elected for the ensuing year.

REPORT OF COMMITTEE ON NEW BOOKS AND MAGAZINE LITERATURE

MR. RICHARD PORTER-BOYER, *Chairman, Newton High School*
MR. FLOYD E. SOMERVILLE, *Newton High School*
MR. GEORGE W. SEABURG, *Hyde Park High School*

New Books

Background to Modern Science.—Needham and Pagel (editors). 243 p. $2.00. Apr. '39. Macmillan. Ten lectures at Cambridge, arranged by committee on History of Science.

An Orientation in Science (by 10 members of U. of Rochester faculty). Watkeys, ed. 560 p. $3.50. McGraw. Apr. '39. A First Year College Text.

The Log of the Sun.—William Beebe. 321 p. $2.50. Holt. A new printing. It goes through the year, month by month, helping us to see the world with a naturalist's eyes.

Photographic Chemicals and Solutions.—Crabtree and Matthews. Am. Photographic Pub. Mar. '39. 360 p. $4.00. Photographic chemistry by two experts associated with the Kodak Co. Fundamental principles and techniques of solution preparation and development. Data, formulas. For amateurs, professionals, X-rays, photo-engraving, etc.

Print Finishing.—Mortensen. 127 p. $2.50. Camera Craft. All steps from wash water to salon wall.

Champlin on Fino Grain (2nd ed.)—Champlin. 160 p. $2.00. Camera Craft. For miniature camera enthusiast.

How to Tone Prints.—Hammond 72 p. 50¢. Am. Photo. Pub. Co. A small book of formulas and instructions. Color without use of color photography, or hand tinting.

Report of the U. S. National Museum, 1938. 121 p. 20¢. Gov't. Printing Office.

Report of Secretary of Smithsonian Institution for 1938. 119 p. 15¢. Gov't. Printing Office.

Fundamentals of Electricity and Magnetism.—Loeb. 554 p. $4.00. Wiley. Revision and enlargement to bring previous text up to date.

Household Physics.—Madalyn Avery. 439 p. $3.50. Macmillan. Apr. '39. Textbook for college students in home economics. Physics, electric apparatus and appliances, to show their close relationship to problems in the home.

History of the Gas Industry.—Stotz and Jamison. 534 p. $3.50. Uses of gas for fuel, light, refrigeration reviewed.

Fluorescence and Phosphorescence.—Hirschoff. 130 p. $1.50. Chem. Pub. Co. of N. Y.

Weather.—Gayle Pickwell. 170 p. Plates, maps. McGraw-Hill Co. '38.

Alternating-current Circuits.—Kerchner and Corcoran. 510 p. $4.75. Wiley. '38. Textbook for junior electrical engineering students (college).

Diesel Engineering; a textbook.—J. W. Anderson. 269 p. McGraw-Hill Co. '38.

Color Photography for the Amateur.—Keith Henney. 281 p. McGraw-Hill Co. '38.

Principles of Electricity and Magnetism.—Gaylord P. Harnwell. 619 p. McGraw-Hill Co. '38.

Photo-elements and their Application.—Bruno Lange. Reinhold Pub. Corp., New York. '38. 297 p.

Modern Atomic Theory; an elementary introduction.—J. C. Speakman. Longmans, Green. '38. 207 p.

New Laws for Natural Phenomena.—Thomas H. Grayden. Christopher Pub. House, '38. 64 p.

The Magic Wand of Science.—Eugene W. Nelsen. 213 p. Dutton. '38.

Mechanics of Materials.—Laurson and Cox. 408 p. Wiley. '38.

Formulas for Stress and Strain.—Raymond J. Roark. 326 p. McGraw-Hill Co. '38.

Great Feats of Modern Engineering.—Edward Flaxman. 287 p. Mill '38.

The Engineer's Sketch-Book of Mechanical Movements, Devices, Appliances, Contrivances, and Details, employed in the design of machinery for every purpose. 6th ed.—Thomas W. Barber. 355 p. Chem. Pub Co. '38.

How to Make Good Movies; a non-technical handbook. 229 p. Eastman Kodak Co. '38.

Lighting Ideas in Photography.—Herrschaft and Deschin. 278 p. McGraw-Hill Co. '38.

How to Organize a Science Club.—Morris Meister. 35 p. 25¢. The American Institute, 60 E. 42nd St., New York.

Modern Methods of Refining Lubricating Oils.—Kalichevsky. 235 p. $6.00. Reinhold. Monograph-Am. Chem. Soc. New Technical Advances through the Year 1937.

Metal Coloring and Finishing (2nd ed.)—Krause. 222 p. $5.00. Chem. Pub. Co. New York.

Also: A long list of new books on science in the Science News-Letter for April 22, 1939, and another list on page 324 of the *Scientific American* for May, 1939.

Magazine Literature

Scientific American

March, 1939.

The Electrical Voice. Page 139
Visualizing Hyperspace. Page 148

April, 1939

Here Comes Television. Page 207
Quicker than the Eye. Photoelectric Temperature Measures. Page 210
The Stubborn Elements.
Delicate physical methods of search. Page 226

Science Digest

March, 1939.

1. Bombing the Battleship. Page 6
2. Jupiter's Satellites. Page 17
3. The Advancement of Science. Page 31
4. Facts, Theories, and Common Sense. Page 37
5. The Science of the Romans. Page 43
6. Measuring the Earth. Page 55
7. Invisible Glass. Page 79
8. Charles Proteus Steinmetz. Page 87

April, 1939.

1. Air Conditioning and the Human Body. Page 1
2. Science and Music. Page 30
3. Releasing the Atom's Energy. Page 59
4. Recent Advances in Astronomy. Page 61

May, 1939.

1. Birth of the Earth. Page 42
2. Engineering in Ancient Rome. Page 45
3. The Science of Seeing. Page 63
4. Peculiarities of Electric Shock. Page 72
5. Powder Metallurgy. Page 75
6. Archimedes, First of the Great Mathematicians. Page 88

Popular Mechanics

March, 1939.

1. Turbine on Wheels. Page 325
2. Miracle of New Color Movies. Page 333

April, 1939.
1. Color "Spies" Join the Army. Page 497
2. Painting Pictures with Light. Page 546

May, 1939.
1. Magic Tubes of Daylight. Page 641

Technology Review

April, 1939.
1. From the Mountain Tops. Page 257
Frequency modulation in broadcasting.

Bell Laboratories Record

January, 1939.
1. Measuring Permeability under Stress. Page 141
2. Template for Graphing Audio-Amplifier Performance. Page 153

February, 1939.
1. Pedro the Voder. (Electric Speech.) Page 170

March, 1939.
1. Spectrochemical Analysis. Page 202

April, 1939.
1. A New Page Teletypewriter. Page 257

THE MARINE BIOLOGICAL LABORATORY

DR. SAMUEL E. POND

The Marine Biological Laboratory is particularly happy to welcome the Eastern Association of Physics Teachers, its members, and guests to our Woods Hole laboratories. This is not the most active part of the year, and you will find some disruption here and there due in part also to the damages of last September's storm, which invaded some of our buildings; but we are glad to have you come here for your deliberation and become better acquainted with this institution. Some time, later, you may wish to visit us when the work of instruction and research is more active, that you may see directly the type and scope of our interests within the biological field.

We have however, placed at your disposal the central laboratory building and arranged some rooms for you to inspect more closely. A few demonstrations of some technical problems, and a glimpse at the literature of the Biological Stations are accessible on the second floor. Also the draughting and photographic room, x-ray suite, library, etc. may be of interest to you as typifying our research equipment. Outside of this building there will be some interest in the Museum, where the specimens of the Woods Hole fauna and flora may seen, and you will be guided to the Yandell Sun Dial across the street, and the nearby Woods Hole Oceanographic Institution and the U. S. Bureau of Fisheries. It is somewhat early for the current activities of the summer season; the research ship Atlantis is not in port, nor is the public aquarium stocked with any live specimens at the Fisheries Station. These are points of interest in Woods Hole you can visit on your next trip.

For your information concerning our institution it may be pointed out

that the Marine Biological Laboratory of Woods Hole has rounded out something over fifty years of activity in instruction and research in zoology and related sections of biology. From the first, the Laboratory has been free of direct control by any college, university, or other institution. In a stricter sense it is national in character, devoted to increasing knowledge about living things and mainly in the life of the sea.

We are under the impression that the early stimulating influence of "The Origin of Species" and the personal touch of both Darwin and Huxley directed workers and students to the great arenas of organic evolution—the seashore. Here lay the great problems confronting the early biologists. Here, still are the great unsolved engimas of Nature; cross-sections of life within reach of the earnest biologist. The great opportunity for access to Nature's storehouse which initiated the early studies at seashore laboratories, brought about intensive development in many places about the world.

This institution is but one of many stations for experiment and study of marine life. Our close relatives in marine laboratories are the famous laboratories at Naples, Italy; and those institutions at Helgoland, Germany; Friday Harbor, Washington; LaJolla and also Pacific Grove, California; Tortugas southeast of Florida; Beaufort, N.C.; Plymouth, England; and many others. Some of the stations bear the initial impacts of economic biology with closely related bureaus or stations for fisheries developments, hatcheries and public aquaria. But at Naples and at Woods Hole there was initiated elementary, technical and advanced instruction, along with research in the field of pure science and so research laboratories, study and class rooms are woven into the construction.

The greater impetus to the founding of marine stations appears to have come from Anton and Reinhard Dohrn, Germans, who went to the Mediterranean coastal waters and finally to Naples Station, where there were developed the Woods Hole biological interests. The Anderson School on Penikese with Louis Agassiz as teacher preceded the work in this village, with active work in 1873. By 1881 Spencer F. Baird of the U. S. Fish Commission had settled upon Woods Hole for a marine laboratory, and workers from this section congregated in Woods Hole. Active work toward an independent laboratory came about as early as 1880 through efforts of the Boston Society of Natural History and the Woman's Educational Association of Boston. Later on more intensive effort was effective, and in 1887 a fund of $10,000 was used to launch the Marine Biological Laboratory. This institution was incorporated in 1888, and its first building opened in July of that year. The structure first built is part of the present Old Main Building.

First director of the Marine Biological Laboratory here was Charles Otis Whitman of Clark University, known at the time for his work in the field of animal behavior. At the start work in Zoology was the chief among the activities but there were added gradually increasing opportunities in Botany, Embryology, and Physiology. For some time a course in compara-

tive psychology was offered by Professor Thorndike and there have been offered courses of lectures as in philosophy, mathematics, etc. At the present time the summer study and lecture courses comprise Invertebrate Zoology, Embryology, Botany, Physiology and Protozoology.

A Supply Department was opened in 1891 to furnish biological material to the schools and scientific institutions. Boats and their crews are busy in collecting living supplies; their floats and storage quarters of "live cars" below carry material for the research work. The Laboratory has also a division given over to publications and a journal "The Biological Bulletin" with its own board of editors.

Our physical plant now comprises some thirty buildings for residence and laboratory work, equipped chiefly for work in the spring, summer and fall. The first portion of the brick building was presented by Mr. Charles R. Crane, and opened in 1914. An extension to this structure was arranged through outside assistance and opened for use in 1925. The brick apartment and dormitory buildings with funds from the General Education Board were available to workers in 1928.

All equipment and personnel of our Laboratory is aimed primarily toward the prosecution of biological research and teaching. We have overrun the allotted space and utilize corridors and quarters originally set aside for maintenance purposes.

The Library which has considerable space in the brick building is the backbone of our activities. It has now grown to fill most of the allotted room and has need of an additional wing for its own activities. For a glimpse of its equipment I may refer to one of its yearly acquisitions (1937), including 1330 current serials, in over twenty languages; 3000 reprints, (with some seven thousand filed in one year) and the addition of 25 back sets. All told the Library comprises some 43,000 bound volumes and over 102,000 reprints, this latter figure, indicating that the library is a work room of great flexibility with its offprints the most fundamental of tools.

In management we have, besides our president and director, a scheme of supervision through five major divisions: Business Administration including dormitories, residences, and general office under a business manager; the Library with its own librarian and staff; the Supply Department, with manager and crew; Biological Bulletin with editor staff and office; and the Division of Chemicals and Scientific Apparatus under a technical manager.

Individuals who gave original impetus to the work and whom we revere for their contributions we look back upon as the pioneers. Among these more prominent, we may refer again to Spencer Baird who was a naturalist of the old school, but a scientific leader, an excellent business man, an executive. He was keenly interested in the development of the fisheries station but directly and indirectly added to the earliest beginnings of the Marine Biological Laboratory. Professor Whitman, for years the director of this Laboratory, was of another type—most quiet and reserved. It was

he who invested in the future and founded, from the start, this institution for research; building from his knowledge of the Naples Station and from his skill in the biological technics. In his own field of skill he was associated with Charles S. Minot and E. L. Mark. We ought also to refer to the early workers and founders, including Alpheus Hyatt, W. K. Brooks (Johns Hopkins), Cornelia Clapp (Mt. Holyoke) David Starr Jordan (University of California) and Burt Wilder (Smith College). Some of these names undoubtedly are familiar to you.

Following these pioneers, we are indebted to the courage and laborious service of men like Jacques Loeb for his painstaking studies on animal response, and his later technical work with proteins, for it was Loeb's work which resulted in our present knowledge of the iso-electric point of gelatin.

Then there was Gilman A. Drew, for fifteen years, assistant director and resident in charge of the Laboratory. He was not only teacher and research worker, but came to be the shaper and skilled leader in establishing the buildings and equipment. Many other workers in biological research have come and left their mark upon the records in science.

It may be of help to you to get a glimpse of activities here. In the summer season we include many research workers of two to four months residence. At times we have as many as 390 investigators and over 200 graduate students, making a total attendance of actual workers in excess of 520. In connection with the summer courses, lectures are arranged for an hour or so each morning starting at nine, followed by laboratory all the remainder of the day. Research work is arranged in accordance with the problems, the living materials and the workers. Evenings are set aside for scientific lectures and once a week a seminar is held for presentation of shorter papers with discussions which encourage the younger investigators in reporting progress of their work.

Finally, it seems worthwhile to emphasize that the effort here is primarily in the interests of advancing our knowledge of biology, which is not so distinct from physics or chemistry as to require a categorically exclusive methodology. It is true, of course, that the facts associated with and which draw upon the basic living phenomena are grouped separately for study and are concentrated in a system characteristic of previous efforts in handling animals and plants. But many of the vital processes are chemical or physical, in nature, and may be approached successfully with the same tools used in the study of the non-living phenomena. It is highly desirable, therefore, to uncover ways and means of coordinating the chemical and physical approaches to studies of living things. As a consequence, teachers of physics face the challenge of a truly scientific interest in the preparation of students for biological research.

There is offered here, as elsewhere, ample opportunity for applying a strictly physical training in the pursuit of knowledge within the general field of biology. The extension of knowledge in the field of radiant energy is closely coupled with studies in medicine, and general physiology; and

so with the phenomena involving translation and transformation of energy in living cells and tissues. There arise repeatedly from associative and cooperative work in studies of the heart beat, velocity of the muscle contraction wave, of the nerve impulse, or the relations between the continuous and discontinuous phases in organs of secretion examples of analysis from the strictly physical point of view. If therefore, in addition to implanting in the minds of the younger generation a real interest in physics, you teachers can find ways to extend the mental horizon so as to establish a flexibility of mind and character which will enhance coordinated and cooperative studies of living processes, we may have the laws of nature unfolded more clearly; for, in the future, it is not so much the strict pursuit of things physical or things chemical or things biological as it is the elementary and fundamental study of basic phenomena. This calls for joint physical, chemical and biological skill. The more successful we are in providing for cooperative studies wherein students experienced in physical and chemical methods work beside biologists, the sooner will our knowledge be resolved into understandable form and the better will applications be successfully made, with much less confusion, than today.

Again, let me say, speaking on behalf of the Marine Biological Laboratory and the workers who make this their foster-home, we are particularly delighted in having you meet here within the field of influence of biology. May you urge the well trained and far-seeing student to bend every effort in making the physics class room a truly profitable work-place, so that at least a few may effectively rub elbows with the biologically trained on problems of basic interest!

PHYSICS AND CHEMISTRY OF SWIMMING

Abstract of Address Given by Dr. Peter V. Karpovich of Springfield College

Dr. Karpovich enumerated several problems illustrating how physics and chemistry apply to swimming. Among these were:

1. Control of buoyancy by inhaling and exhaling.—Archimedes principle.
2. Greater ease of floating in salt water.
3. Effect of water pressure on breathing through a tube under water. (Tube could not be over $4\frac{1}{4}$ feet in length.)
4. Overcoming of water resistance.—Stream-lining.
5. Hydroplaning.

He then showed a model of a resistograph which he uses to determine the formula of resistance. By means of a 3 h.p. motor, the speed of which can be varied, the swimmer is drawn flat on his face through the water in a tank. A calibrated spring-balance measures the force, and a graph is made on a revolving smoked drum. The formula is found to be:

$$\text{Coef.} = .65\ V, \text{ with a discrepancy of } V.03.$$

Hydroplaning shows resistance increase.

To find how much force is necessary to propulsion. (Force = resistance.)

Experiments were carried out to determine how much propulsion a swimmer gets from his arms, and how much from his legs. To test propulsion, the swimmer propelled himself using legs alone and holding a water-ball in the hands. He then held the water-ball with his feet and propelled himself with arms alone.

Using a crawl stroke, a good swimmer was found to get 70% propulsion from the arms and 30% from the legs.

A comparatively poor swimmer got 80% from the arms and 20% from the legs, while a very poor swimmer got 90% from the arms, and 5% or almost none from the legs.

From the chemical point of view, 20 reasons, he said, had been given why swimming pools should be abolished.

Individual differences determine why some swimmers can swim faster than others. This depended on the behavior of oxygen, which was studied in swimming tests of 200 feet or more without breathing. Lactic acid forms in the muscles and this has to be burned up, at least in part, so oxygen is necessary. The amount needed depended on speed, but was not a linear proportion.

Speed Ft. per sec.	Oxygen in Liters per min.
1.5	3
3.0	5
4.5	10
5.4	18
6.0	28

Swimmer doing a crawl stroke and not breathing.

40 yds. in 23 sec..... 6 liters.
40 yds. in 29 sec.....3.8 liters.

A person with a good oxygen debt could swim faster or sprint faster

O. D. (Oxygen Debt)	M. C. (Maximum Consumption) oxygen in liters per minute while swimming.
A—12	3
B— 6	4

½ min.	A—13½ (or O.D. +½ M.C.) (or 12 +1½ =13½)	B— 8 (or O.D. +½ M.C.) (or 6 +2 =8)
20 min.	A—72 (or O.D. +20 M.C.) (or 12 +20 ×3 =72)	B—86 (or O.D. +20 M.C.) (or 6 +20 ×4 =86)

BIOLOGICAL ENGINEERING

PROFESSOR JOHN W. M. BUNKER
Massachusetts Institute of Technology

One hundred years ago there was published in London a pocket-sized volume entitled,

"A System of Natural Philosophy in which the Elements of that Science are Familiarly Explained and Adapted to the Comprehension of Young Persons: with appropriate questions on each page for the examination of scholars; By John L. Comstock, M.D."

Glancing through the preface one finds that "this work contains the usual branches comprised in a course of Natural Philosophy, viz. PROPERTIES OF BODIES—MECHANICS—HYDROSTATICS—HYDRAULICS—PNEUMATICS—STEAM ENGINE—ACOUSTICS—MUSIC—OPTICS—ASTRONOMY—ELECTRICITY and MAGNETISM, with the Mariner's Compass." It appears to be a textbook in elementary physics. One notes that it was written by a physician.

The names "physician" and "physicist" are, of course, derived from the same root, φύνις a word which the Greeks had to designate the natural, material world, as distinguished from the spiritual, mental, or moral. Physician or physicist deals with bodies, a body being, according to Dr. Comstock, "any substance having length, breadth and thickness." In the early days, physicians were often more than practitioners, they were also natural philosophers, lovers of knowledge. As precise recorders of their observations of natural phenomena, they were scientists, since science is merely knowledge arranged in orderly fashion. Pioneers in scientific observation did not restrict themselves to any one field; the earth and the life upon it, were the objects of their attention. "Natural philosophy" designates appropriately their interests. It included natural history, medicine, and alchemy. There was no sharp differentiation of physics as we now understand that subdivision of natural science.

The nature of man has always challenged the attention of men. Biology which relates to life and the products of living things developed gradually into a science from the orderly descriptions and classifications of forms, followed by a period of inquiry into the nature of these forms, the changes which they were observed to undergo and the analysis of life in general into unit processes. Thus there developed within the broad field of biology a subdivision of specialization on function which acquired the designation, "physiology." The demonstration that the functions of physical life are largely manifestations of chemical reactions enabled the physiologist to utilize the expanding knowledge of organic chemistry in his own studies, and to develop the still further specialized branch of science which today is known as biological chemistry.

Other subdivisions of science likewise became subdivided and specialized and the tendency to regard these subdivisions as separate entities obscured their real relation to each other as complementary parts of a whole.

Chemists, physicists, biologists, developed each their own new vocabulary in describing the minutiae of their expanding knowledge. The natural philosopher disappeared and his place was taken by numerous specialists.

The recent rediscovery—or should one say convincing proof—that the subject matters of chemistry and of physics have essential unity, that chemist and physicist alike are concerned with the structure of matter and its behavior, tended to reverse the swing from divergence to convergence of interests. Chemical secrets are being resolved by the data of experimental and theoretical physics. The physical chemist supplies the liaison.

Living and non-living matter have in common a structure of matter in molecules, atoms, electrons, all subject to the same forces, and obeying the same laws of energetics. We are living in an age in which natural science recognizes, because of proof, what the natural philosophers accepted on faith, that the quick and the dead, the animate and the inanimate all are a part of mother earth, arranged for a brief span in a particular configuration, but ultimately destined to be returned to dust. Expansion of knowledge by specialization; utilization of specialization by cooperation; these have been the patterns of the growth of science.

Medicine and engineering may be mentioned as examples of combinations of art with applied science, medicine being based upon biology and engineering having been born of physics. Both medicine and engineering have taken unto themselves that which is pertinent from the richness of chemical knowledge and each has become more efficient by such a merger.

Convergence of specialized fields comes about when some fundamental discovery discloses the underlying unity, the basic processes, of two branches of science which have developed apparently divergently on less fundamental and apparently unrelated bases. A generation ago it was easy to distinguish between a chemist and a physicist; the latter dealt with matter in bulk, the former with changes in molecular constitution. There still exists what might be called a plumbing type of physics and the culinary type of chemistry, but in their interpretative and many of their operational aspects the two sciences are now completely merged, to their very great mutual advantage. Every competent chemist is to some degree a physical chemist, and no observer of physical interactions can escape observation of chemical changes. It was only lack of information which compelled men to proceed along different lines based on imperfect conceptions of what appeared in their ignorance to be different sets of fundamental laws.

We now have learned a little more of the truth, and perceive that the physical laws which formulate the relations of matter and energy in the lifeless world also apply to these relations in the world of the living. Biological science is one category of facts, relations and laws concerning matter and energy, just as chemistry and physics are other categories of the same broad classification. No boundaries exist to delimit sharply the fields of natural science; each merges into the other as the grass on the suburban lawn merges with that of the neighbor's yard. Names which are attached

to centers of interest in each field are for convenience in description and reference and do not represent individual factual entities.

It is well recognized that man's achievement, all through the ages, has depended to a large degree upon the tools at his disposal. Already the techniques of experimental physics and chemistry have been applied in the study of biology with success, and the greater precision of measurement and of description of biological phenomena made possible thereby have changed the character of modern biology from descriptive to analytical. It is especially true in biology, due to the unpredictable idiosyncrasies of living specimens brought about by individual variations of environment or of heredity, that only by repetition can tests of theory establish truth. True repetition can be effected only when reproducible precision of essential measurement characterizes the tests. Chemical and physical measurements in biological investigation have supplied the precision necessary for successful experimentation.

As a result of the era of specialization in all fields of science, the biologist trained in the past finds himself today incompletely informed of the finest techniques of his brother specialists in physics, chemistry and mathematics. To acquire a comprehensive background of biological information, he has not had time to specialize in other sciences; the magnitude of the variety of experimental procedures in the various fields is beyond the comprehension and attainment of one mortal, it would require a superman.

Cooperation of specialists would seem to supply one answer to the dilemma which each faces. Cooperation means working together, it requires the ability to give and take mutually, and this give and take must not degenerate into "You give and I take." Cooperation requires adjustment of ideas when ideas are based upon imperfect premises. Cooperators must be able to reason logically and to yield to logic. They must be able to argue without acrimony, to convince or be convinced. If the answer were known in advance, there would be no need for search or research. Since the answers are not known, they must be sought by the formulation of hypotheses and the experimental testing thereof. This requires information and reasoning together with experimental skills.

Where there is a little knowledge but not enough, two heads should be better than one in gaining more. But man is a stubborn animal; and scientists are prone to be opinionated. The line between confidence and conceit is vague; the one quality is necessary for achievement, but the other is irritating to one's fellow man. Hence there are problems of human behavior and human reaction to be met with in cooperation. Without patience, differences of opinion are rarely resolvable. The very imperfection of words to convey the meaning intended by the user requires meticulous definition in discussion of scientific matters—and in other misunderstandings as well. To be specific, the biologist, chemist and physicist are conventionally trained in different terminologies and approach their problems with somewhat different attitudes. Cooperation does not come about like the amalgamation of mercury and other metal. It is something to be

cultivated and nourished like a delicate organism until it acquires a sturdy habit of existence.

Cooperation among human animals is an art which can be learned and fostered, but it appears not be an instinct. Scientists are individualists—which is to say, they are human. While it is true that the mental capacity of most of us is insufficient, in view of the imperfect technic customary to contemporary mankind in the utilization of his talents, to permit one head to equal two, it is, nevertheless, possible for one efficiently filled head to know enough of two branches of science to enable its possessor to work efficiently with one on problems in the other with at least intelligent comprehension. To train an accomplished physicist to appreciate the reasonable expectancy of the unpredictable in biologic phenomena is almost as difficult as it is to add to the accomplished biologist an adequate appreciation of the weapons of the physicist. It is possible, however, by a new pedagogical approach, to train an individual in biology and in physics contemporaneously from the ground up.

As the Massachusetts Institute of Technology, a recently established curriculum offers such a type of training. Beginning with the regular freshman year subjects common to all courses of study at the Institute, each subsequent year includes Biology, Chemistry, Mathematics and Physics, leading to the award of two degrees at the end of the fifth year, the B.S. in Biophysics, and the M.S. in Biological Engineering.

The choice of the name "biological engineering" is the result of much thought and consultation, and it has been adopted in spite of its temporary abandonment when we were first searching for the precisely appropriate title to describe our objective. The name biophysics is not sufficiently definitive, and biochemistry is insufficiently inclusive. Such varied etymological combinations as biurgy, biodynamics and biotechnology were examined and discarded. The designation accepted was urged by Dr. Vannevar Bush as being appropriate because our objective so aptly conforms to the well-known definition of engineering as "the art of organizing and directing men and nature for the benefit of the human race." Within this concept lies ample scope for every activity from instrumentation to theory, including biophysics and biochemistry (which, in fact, contribute greatly to the meaning of physiology) so long as the major objective is the marshalling of all available resources to aid biology for the benefit of humanity.

Biological Engineering is not a new art, but the designation recognizes the existence of a product of natural evolution in the applications of science, just as a half-century ago there was recognized an art of chemical engineering. The art of training chemical engineers did not emerge full-fledged at its christening; for fifteen years it followed the historical method of pedagogical treatment, until William Walker replaced the plan of descriptive treatment of detailed industrial procedures and introduced the pedagogical plan of instruction in the unit processes such as distillation, dehydration, and heat transfer which are common to many industrial applications. Thereupon chemical engineering spread its wings and took

off in full flight which it still successfully maintains. We hope for a repetition of this experience in the case of Biological Engineering.

Among the technical skills in which training is offered in this curriculum may be listed, the design, construction, and operation of vacuum tube amplifier circuits; machine tool work, welding, hard and soft soldering; the fabrication of glass-metal seals; manometry and the use of high vacuums; methods for maintaining temperature control; photography and photometry; optical and radiation measurements, spectroscopy; the production and control of electron beams and X-rays; vitamin, enzyme, and hormone work with animals; measurements of electrophoresis and the electrokinetics of membranes; radioactivity; electromagnetic vibrations; super and ultra sonics.

Fifty potential employers in the industries employing research in food, drugs, medicine, physiology, utilization of agricultural products, and government and university laboratories have expressed the desire to be informed when men of suitable personality with this type of training become available.

During the period of five or six years in which this plan has been incubating, certain achievements have resulted from cooperation between physicists, biologists, chemists and engineers which may indicate the sort of thing which can be accomplished by the biological engineer. For instance, the skill of an organic chemist led to the production of a peroxide of secondary butyl alcohol through irradiation with ultraviolet light. A chemical novelty, this compound was demonstrated by a biological colleague to be lethal to bacteria and fungi. Due to its relatively low surface tension and therefore predictable penetrability into living tissue, it is particularly useful in alleviation of fungus diseases of the skin such as the so-called Athlete's Foot. For similar reasons it has proved extremely efficacious in treatment of dental infections, and appears to have cured "incurable" cases of pyorrhea. This material has been made available to the medical and dental professions and is already serving the public good.

The pulse rate is a symptom of certain organic conditions in the body, whether of man or laboratory animal. To take the pulse rate of the white rat in vitaminic deficiency diseases proved to be impractical by ordinary methods; the rate is between 400 and 500 beats per minute, too fast to count. The problem was referred to an electrical engineer who devised an apparatus for picking up at the skin the minute electrical changes in the heart at each beat, amplifying them with vacuum tubes, and recording the number per minute on the dial of a millivolt meter. This electrocardiotachometer has been used successfully in the hospital operating room to record the pulse of a patient while under anaesthesia, thus releasing to the anaesthetist the use of a hand previously required for taking the pulse of the patient.

A constituent of animal tissues known as cholesterol, and a similar chemical substance in plants, known as ergosterol, can be converted to vitamin D by treatment with ultraviolet of appropriate wave length. Similar

chemical change has been induced by us without ultraviolet by capturing the energy of particles of nitrogen gas or other substances, excited in the electromagnetic field of a short-wave radio oscillator. The development of this art involved biologist, chemist, physicist, and electrical engineer. Vitamin D produced by "wireless" as it were, is being manufactured today and used by the drug industry at a saving in cost to the public.

The problems of importance to the welfare of mankind, which appear to be susceptible of solution by the biological engineer are present on every hand. The crystalline protein viruses of mosaic disease appear to multiply in the tissues of the host; is this an unknown type of biological reproduction or not? Investigation of such chemical aggregates is going forward intensively at the hands of biologists, who utilize the tools of physics and chemistry. Vast quantities of skim milk have been a by-product of times of over-production in the dairy industry; today, one may purchase food products in glistening transparent wrappings that theoretically are edible, having been made from milk casein. The destruction of wooden piling and other timbers in Boston Harbor due to the activities of ship worms and marine borers amounts to millions of dollars in a single year. The biologist seeks out the causes; chemical science indicates the substances toxic to the destructive pests, engineering supplies the methods for application of the biochemical data on a large scale to combat the biological menace.

Fathered by physics and engineering, there has emerged the cyclotron with which numerous isotopes of common chemical elements can be rendered radioactive for periods of time which permit studies of metabolism of these elements in the living body. These tagged atoms are mingled with a host of untagged brother atoms and the course of their processions through the body can be traced with physical detectors of gamma radiations, developed in connection with studies of cosmic rays. Certain chemical atoms have been proved to become quickly concentrated in particular structures, as for instance iodine in the thyroid gland. It is known precisely in what period of time one half of the radioactive atoms of any element will give up their last burst of excess energy, and such atomic bombardment will in all probability soon be timed to take place in the proper locations inside the diseased body where destruction of malignant cell growths becomes necessary for cure of the patient. Super-high voltage X-rays of great speed and penetration are already used for treatment of cancer.

Man can control the myriad forms of life which share his existence on earth and compete with him for supremacy, only after he learns how living mechanisms, including his own, operate in living. The secret of life, if it is to be resolved, will yield to the investigator of the nature and energies of molecular reactions in protoplasms. As means for his investigations there is already on hand a rich supply of technics for precise objective measurements, developed in the varied fields of science. The methodical planning and calculated foresight of the engineering method are insur-

ance against failure in the applications of scientific findings by the Biological Engineer for the betterment of the common weal.

Herein lies a virtual frontier of applied science, ready for the young man of ambition, imagination and courage. Here he may set his own course knowing that few are the traces of previous explorers. Even though he fail of the goal he has set he cannot fail to reach some new vantage point, so long as he rigorously requires of himself (in the words of Pavlov) that he shall "never begin the subsequent without mastering the preceding." Then like Christopher Columbus, no more adept at navigation than many of his colleagues but surpassing them all in confidence and perseverance, alert to capitalize the unexpected observation, even though he lose his way, it may be only to have a new world swim into his ken.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problems, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1586, 1591, 1597, 1590. *D. L. MacKay, New York.*

1598. *Walter R. Warne, Minneapolis.*

1595. *Edward H. Umberger, Chicago.*

1604. *Proposed by Howard D. Grossman, New York.*

Show that $\sqrt[i]{i} = 23\frac{1}{4}$ (approximately), where $i = \sqrt{-1}$.

Solution by Alan Wayne, New York.

From Euler's well known relation: $e^{\pi i} = -1$.

We obtain $e^{\pi i/2}=i$ whence $e^{\pi/2}=\sqrt[i]{i}=4.8$ (approximately).

This value does not agree with the value claimed by Mr. Grossman. Note by Editor:

Mr. Trigg and Mr. A. E. Andersen point out that $\sqrt[i]{i}=e^{(2k+1/2)\pi}$, where k is any integer. Hence $\sqrt[i]{i}$ is multiple valued and real.

When $k=-1$, $\sqrt[i]{i}=0.038$.

When $k=0$, $\sqrt[i]{i}=4.81$.

When $k=1$, $\sqrt[i]{i}=2576$.

The value of $e^{\pi}=23\frac{1}{7}$ (approximately).

Solutions were also offered by E. C. Varnum, Grand Rapids, Mich., Dr. A. E. Andersen, Amherst, Mass., and C. W. Trigg, Los Angeles, Calif.

1605. *Proposed by Hugo Brandt, Chicago.*

For the curve $3 \arctan y/x=\arctan \dfrac{y}{x-2}$, find

(a) the maximum y and the corresponding x,
(b) the asymptote.

Solution by the Proposer

Call $\arctan y/x=\alpha$; then $\arctan \dfrac{y}{x-2}=3\alpha$

and hence: $y=x \tan \alpha$; $y=(x-2) \tan (3\alpha)$.

These are two straight lines intersecting at a point of the curve for a chosen α. In other words the curve is the locus of all the intersections for all possible α's.

(a) To find the maximum y, $dy=0$.

Eliminating x: $x=y \cot \alpha$, inserting this in $y=(x-2) \tan (3\alpha)$ we get $y=\tan (3\alpha)(y \cot \alpha-2)$, from which $y=f(\alpha)$.

$$y=\frac{2 \tan (3\alpha)}{\cot \alpha \tan (3\alpha)-1}=\frac{2}{\cot \alpha-\cot (3\alpha)}$$

$$\frac{2}{y}=\cot \alpha-\cot (3\alpha).$$

Differentiating

$$-2y^{-2}\frac{dy}{dx}=-\frac{1}{\sin^2 \alpha}+\frac{3}{\sin^2 (3\alpha)}=0.$$

Therefore

$$3 \sin^2 \alpha=\sin^2 (3\alpha)$$

$$\sqrt{3} \sin \alpha=\sin (3\alpha).$$

Now

$$\sin 3\alpha=3 \sin \alpha-4 \sin^3 \alpha;$$

$$\therefore \quad \sqrt{3} \sin \alpha=3 \sin \alpha-4 \sin^3 \alpha$$

$$4 \sin^2 \alpha=3-\sqrt{3} \quad \text{and} \quad \sin \alpha=\tfrac{1}{2}\sqrt{3-\sqrt{3}}.$$

We find

$$\cot \alpha=\sqrt{\frac{2\sqrt{3}+3}{3}}$$

and

$$\cot(3\alpha) = -\sqrt{\frac{2\sqrt{3}-3}{9}}.$$

Hence

$$\frac{2}{y} = \cot\alpha - \cot(3\alpha) = \sqrt{\frac{3+2\sqrt{3}}{3}} + \sqrt{\frac{2\sqrt{3}-2}{9}}.$$

From which

$$y = \sqrt{3(2\sqrt{3}-3)} \quad \text{and} \quad x = \sqrt{3}.$$

(b) The asymptote is the tangent on the infinite point of the curve, which can only happen if $y = x\tan\alpha$ and $y = (x-2)\tan(3\alpha)$ are parallel: $\tan\alpha = \tan(3\alpha)$; since $\alpha \neq 3\alpha$ (except for $\alpha = 0$, in which case the two lines are coincident) we must assume $3\alpha = n\pi + \alpha$, since $\tan(n\pi+\alpha) = \tan\alpha$.

$$\therefore 2\alpha = n\pi;\ \alpha = n\frac{\pi}{2},\ \text{a multiple of } 90°,\ \text{for } n=1,\ \alpha = \frac{\pi}{2}.$$

Eliminating y, we get $\dfrac{x-2}{x} = \dfrac{\tan\alpha}{\tan(3\alpha)}$ which is indeterminate for $\alpha = \dfrac{\pi}{2}$.

By the usual method the limit of this fraction is found to be 3, and $x = -1$, the equation of the asymptote.

A solution was also offered by Chas. W. Trigg, Los Angeles.

1606. *Proposed by Marvin Hirsch, Lewis Institute, Chicago.*

Write the fraction $\dfrac{1}{x^{5/6}+1}$ with a rational denominator.

Solution by John F. Wagner, Lewis Institute, Chicago.

The denominator can be considered as the first factor of the difference of two sixth powered numbers. Or in symbols, we know that

$$A^6 - B^6 = (A+B)(A^5 - A^4B + A^3B^2 - A^2B^3 + AB^4 - B^5)$$

and if we put

$$A = x^{5/6} \quad \text{and} \quad B = 1,$$

we see that

$$(x^{5/6}+1)[(x^{5/6})^5 - (x^{5/6})^4 + (x^{5/6})^3 - (x^{5/6})^2 + x^{5/6} - 1] = x^5 - 1.$$

Thus for our problem, of both terms of the fraction are multiplied by

$$x^{25/6} - x^{10/3} + x^{5/2} - x^{5/3} + x^{5/6} - 1.$$

Then

$$\frac{1}{x^{5/6}+1} = \frac{x^{25/6} - x^{10/3} + x^{5/2} - x^{5/3} + x^{5/6} - 1}{x-1}.$$

Solution was also offered by C. W. Trigg, Los Angeles.

1607. *Proposed by Norman Anning, University of Michigan.*

Exhibit $x^6 + 27y^6$ as the product of its quadratic factors and show that, when k is any odd integer greater than one, $27^k + 1$ has three factors of the same order of magnitude.

Solution by Proposer

$$x^6+27y^6=(x^2+3y^2)(x^4-3x^2y^2+9y^4)$$
$$=(x^2+3y^2)(x^2+3xy+3y^2)(x^2-3xy+3y^2).$$

Let $k=2n+1$ where n is any positive integer.

$$1+27^k=1+3^{3k}=1+6^{6n+3}=1+27(3^n)^6.$$

This can be exhibited as the product of three factors by putting $x=1$, $y=3^n$ in the above identity.

$$1+27^{2n+1}=(1+3^{2n+1})(1+3^{n+1}+3^{2n+1})(1-3^{n+1}+3^{2n+1})$$

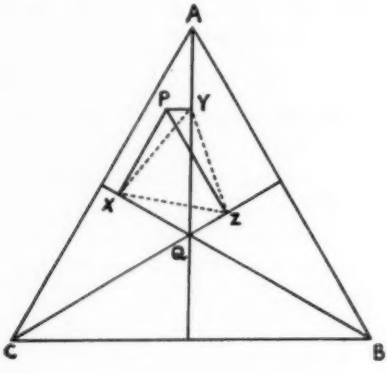
and the ratio of any factor to any other is not significatly different from 1.

When $n=1$, the factors of $1+27^{2n+1}$ are 28, 37, 19.
When $n=2$, the factors of $1+27^{2n+1}$ are 244, 271, 217.
When $n=3$, the factors of $1+27^{2n+1}$ are 2188, 2269, 2107.

A solution was also offered by C. W. Trigg.

1608. *Proposed by Lawrence R. Schoenhals, Huntington, Ind.*

From any point P within an equilateral triangle, draw perpendiculars to the medians. The triangle formed by joining the feet of these perpendiculars is equilateral.



Solution by Aaron Buchman, Buffalo, N. Y.

Since the three medians of equilateral triangle ABC, intersecting at Q, form six angles, each 60°, it is easily shown that

$$\angle XPZ=\angle ZPY=60°.$$

Since

$$\angle PXQ=\angle PYQ=\angle PZQ=90°$$

then

P, Q, X, Y, Z lie on a circle with PQ as diameter.

Thus

$$\angle XYZ=\angle XPZ=60°$$

and

$$\angle ZXY=\angle ZPY=60°.$$

Therefore triangle XYZ is equiangular and also equilateral.

NOTE: The above proof is valid if point P lies outside triangle ABC.

Solutions were also offered by Thomas A. Pickett, South Weymouth, Mass., John P. Hoyt, Cornwall, New York, D. L. MacKay, New York City, M. Kirk, West Chester, Pa., S. E. Field, Ironwood, Michigan, D. F. Wallace, C. W. Trigg, Los Angeles, California, John F. Wagner, Chicago, Ill., Arthur Danzl, Collegeville, Minn.

1609. *Proposed by C. W. Trigg, Los Angeles City College.*

Show that there are only two five-digit integers, each with three like initial digits and each of whose squares is composed by distinct digits.

Solution by J. M. Maxey, Asbury College, Wilmore, Ky.

Let "n" be the number sought. Evidently there are nine fields of numbers to be examined, the lowest being the numbers from 11101 to 11199 inclusive.

The squares of all five-digit numbers have either nine or ten places. Therefore "n"^{2} is composed of the ten digits 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0 if necessary. Now any number composed of these distinct digits is a multiple of nine. Therefore "n" is a multiple of 3, and therefore there are only 33 numbers in each of the nine fields to be examined.

By inspection the squares of 33303 and 33399 we find the first two digits are alike in each and are the same in both. Hence "n" is not in that field.

The same thing is also true for the fields of the 6's and 9's, so by actual trial in the other six fields we find the two numbers sought to be 55524 and 55581, the squares being 3082914576. $n^2=3089247561$.

NOTE: The squares are readily found by addition after the first squares in each field are found.

$$\begin{array}{lll} \text{Now } (a+9)^2=a^2+18a+81 & & \\ \qquad (a+6)^2=a^2+12a+36 & \text{difference is } 6a+45 & \\ \qquad (a+3)^2=a^2+6a+9 & \text{difference is } 6a+27 & \text{difference is } 18. \end{array}$$

Therefore if the difference of two squares plus 18 be added to the larger square it gives the square of the next larger multiple of 3.

Solution was also offered by the Proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1608. *Kenneth Rohde, Clyde, Ohio High School.*

1608. *Enid Golding, Worley, Idaho.*

PROBLEMS FOR SOLUTION

1622. *Proposed by Norman Anning, University of Michigan.*

AB and CD are fixed line segments in a plane. P moves along AB and Q along CD in such a way that $AP:PB=CQ:QD$. Prove that the sum of the areas of triangles ABQ and CDP is constant. Note that area ABQ and AQB are made equal in magnitude but opposite in signs.

1623. *Proposed by John P. Hoyt, Cornwall, N. Y.*

Reduce to lowest terms

$$\frac{6x^4+19x^3-4x^2-2x-12}{3x^4-19x^3-33x^2-28x-14}.$$

EDITOR'S NOTE: In solving 1623, please report how much time to do it is required.

1624. *Proposed by Cecil B. Read, Wichita, Kansas.*

Prove that $m(x^3-3xy^2)+y^3-3x^2y=0$ represents three straight lines equally inclined to one another.

1625. *Proposed by James G. Go, Cebu, Cebu, P. I.*

Find the formula for a number such that when the number is divided by each of the integers 3, 5, and 7 the remainders will be a, b, and c respectively.

1626. *Proposed by S. E. Field, Ironwood, Mich.*

On the sides of any triangle ABC, isosceles triangles AFB, BDC and AEC are constructed each having base angles 30°. Show that triangle DEF is equilateral.

1627. *Proposed by Albert A. Schwartz, Washington, D. C.*

Construct a triangle given the base, the median to the base and the bisector of the vertex angle. Also please include any history you may have of the problem.

SCIENCE QUESTIONS

October, 1939

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Ave., S.E., Cleveland, Ohio.)

This department is a forum for discussing Tests, Experiments, Pedagogical Questions, Scientific Happenings. Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific) Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, Any Problem or Question that will help teachers to make Science Teaching interesting.

The discussion usually takes the Question and Answer Form. Readers, whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.

Contributors are elected to the GQRA (Guild of Question Raisers and Answerers).

Two hundred and ninety (290) are already members.

Send in your question or answers.

GQRA—NEW MEMBERS—OCTOBER, 1939

291. Walter B. Juhnke, Manley H.S., Chicago, Ill.
292. Cecil B. Read, University of Wichita, Wichita, Kansas.
293. La Verne Koelsch, Mercy H.S.
277. (Correction). Marion Wiegel, Mercy High School, Milwaukee, Wis.

AGREE OR DISAGREE?

862. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.* (*Elected to the GQRA, No. 292.*)

In discussing standard units of dry and liquid measure, Thomson's *Higher Arithmetic*, published in New York in 1855, says, "It is customary, at the present day, to determine *capacity* measures by the weight of distilled water which they contain. This is evidently more accurate than the former measurement by cubic inches."

Would you agree or disagree with this statement? Why?

FROST TEMPERATURE

863. *Proposed by Arthur L. Hill, Peru, Neb.* (*GQRA, No. 115.*)

Why and how is the distinction made between freezing as 32 degrees F. and "frost temperature," 40 degrees?

THE SLEEPING CANARY

864. *Proposed by La Verne Koelsch, Mercy High School, Milwaukee, Wis.* (*Elected to the GQRA, No. 293.*)

Why doesn't a canary fall off its perch when sleeping?

THE "CUCKOO" BIRD TEST

865. *Submitted by Walter B. Juhnke, teacher of Zoology, Manley High School, Chicago, Ill.* (*Elected to the GQRA, No. 291.*)

A test designed to stimulate interest in birds.

1. What bird can fly backward?
2. What bird lays "Easter eggs"?
3. What bird kills venomous snakes and eats them?
4. What comparatively small bird is courageous enough to fight off crows and hawks that come too near to its nest?
5. What birds build nests that swing like baskets from the end of a limb?
6. The fastest bird flies at the rate of one-hundred and sixty-five miles per hour. Can you name it?
7. What birds have tails over twenty feet in length?
8. What flying bird has a wing spread of from nine to ten feet?
9. What birds fasten their young to the nest so that they cannot fall out?
10. What bird has a bill nearly as large as its body?
11. What bird can fly under water?
12. What bird uses its moustache to help it catch insects?
13. What bird has claws on its wings?
14. What birds build their nests from four to twenty feet in the ground?
15. What bird is trained to catch fish for man?
16. What bird has a "rubber neck"?
17. What bird hisses, spits, and vomits food at its enemies?
18. What bird annually makes a twenty-four hundred mile non-stop flight over the ocean?
19. What bird carries water to cool the eggs in its nest on hot summer days?
20. What bird holds its egg on its feet while incubating it?
21. What bird dives at the flash of the gun, and is usually under the water before the shot reaches it?

22. What bird plasters the door shut to keep his wife at home?
23. What bird lays its egg in the nest of some other bird, thus imposing on it the responsibility of rearing its young?
24. What bird lays eggs that average three pounds in weight?
25. What bird feeds its young by pumping regurgitated milk into the throat of its young?

DO YOU KNOW THE ANSWERS?

(*Propose questions with quick answers for this section of* SCIENCE QUESTIONS. *Classes and teachers are invited to participate*)

(Questions 51–60 are "lifted" from the Plain Dealer's "Guess Again".)

51. What animal gives birth to its young during the long sleep of hibernation?
52. What is the only bird that can fly backwards?
53. What is the largest creature the waters have ever known?
54. What creature has the curious habit of swallowing some hard indigestible substance before it hibernates?
55. What animal, because of his keenness of sense of smell and his apparent understanding of the wiles of man, is the hardest to trap?
56. What bird is always in continuous flight away from its nest?
57. Many of our highways and railways have been built upon the trails of what animal?
58. What animal thumps on the ground with its feet to communicate with its fellows?
59. What animal besides the kangaroo carries its young in a skin pouch?
60. What American big-game animal is the longest jumper?

ANSWERS

41. If the skull is fractured, there may be a dent; otherwise the tissues are filled with healing lymph and a swelling is the result.
42. Again—"What is the most recently discovered vitamin?" One Professor of Biology said facetiously, "X, Y, Z."
43. Crawfish and Crayfish—Which? (Look in a Zoology text.)
44. Fish contains phosphorus. Phosphorus is reckoned a necessary constitutent of the brain. Therefore, fish is a brain food. Is this good logic?
45. Where to obtain SEED of white as well as sweet potato?—Please collect some seed and forward to Sister Mary Stanislaus Costello, Mercy H.S., Milwaukee, Wis.

BOOKS RECEIVED

Our Natural Resources and Their Conservation, by A. E. Parkins, George Peabody College for Teachers, Nashville, Tennessee, and J. R. Whitaker, University of Wisconsin, Madison, Wisconsin. Second Edition. Cloth. Pages xiv+647. 14.5×23 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $4.00.

Textbook of Organic Chemistry, by E. Wertheim, Professor of Organic Chemistry in the University of Arkansas. Cloth. Pages xiv+830. 15× 23 cm. 1939. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa.

The Nature of the Atom, by G. K. T. Conn. Cloth. 115 pages. 12×18.5 cm. 1939. Blackie and Son, Limited, 50 Old Bailey, London, E. C. 4. Price 3s. 6d. net.

The Nature of the Electron, by G. K. T. Conn. Cloth. Pages vi+78. 12×18.5 cm. 1938. Blackie and Son, Limited, 50 Old Bailey, London, E. C. 4. Price 3s. 6d. net.

Modern-School Solid Geometry, by Rolland R. Smith, Specialist in Mathematics Public Schools, Springfield, Massachusetts, and John R. Clark, The Lincoln School of Teachers College, Columbia University, New York, N. Y. Cloth. Pages viii+248. 12.5×20.5 cm. 1939. World Book Company, Yonkers, New York. Price $1.28.

College Algebra, by Joseph B. Rosenbach, Professor of Mathematics, and Edwin A. Whitman, Associate Professor of Mathematics, The Carnegie Institute of Technology. Revised Edition. Cloth. Pages x+431+xxxviii. 13.5×20.5 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.25.

The Chemistry of Organic Compounds, by James Bryant Conant, President of Harvard University, Formerly Sheldon Emery Professor of Organic Chemistry, and Revised with the Assistance of Max Tishler, Research Chemist, Merck and Company. Cloth. Pages x+658. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

The Nature of Crystals. by A. G. Ward, Scholar of Trinity College, Cambridge. Cloth. Pages vii+114. 12×18.5 cm. 1938. Blackie and Son, Limited, 50 Old Bailey, London, E. C. 4. Price 3s. 6d. net.

A Laboratory Introduction to Animal Ecology and Taxonomy, by Orlando Park, Associate Professor of Zoölogy, Northwestern University; W. C. Allee, Professor of Zoölogy, University of Chicago; and V. E. Shelford, Professor of Zoölogy, University of Illinois. Cloth. Pages x+472. 14×20.5 cm. 1939. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $2.00.

Teaching Arithmetic in the Elementary School, Volume III, Upper Grades, by Robert Lee Morton, Ohio University, Athens, Ohio. Cloth. Pages x+470. 13.5×20.5 cm. 1939. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price $2.80.

Teaching Nutrition in Biology Classes, by N. Eldred Bingham, Teachers College, Columbia University, New York, N. Y. Contributions to Education, No. 772. Cloth. Pages viii+117. 15×23 cm. 1939. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

Introduction to Atomic Physics, by Henry Semat, Assistant Professor of Physics, The City College of The College of the City of New York. Cloth. Pages xv+360. 14×21.5 cm. 1939. Farrar and Rinehart, Inc., New York, N. Y. Price $3.50.

The March of Mind, A Short History of Science, by F. Sherwood Taylor. Cloth. Pages xiv+320. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

Elements of Plant Pathology, by Irving E. Melhus, Professor of Plant Pathology and Head of the Department of Botany, and George C. Kent, Instructor in Plant Pathology, Iowa State College. Cloth. Pages x+493. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

The Biology of Bacteria, by Arthur T. Henrici, Professor of Bacteriology, University of Minnesota. Second Edition. Cloth. Pages xiii+494. 15×22.5 cm. 1939. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $3.60.

The World of Insects, by Carl D. Duncan, Professor of Entomology and Botany, San Jose State College, and Gayle Pickwell, Professor of Zoölogy, San Jose State College. Cloth. Pages ix+409. 15×23 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street New York, N. Y. Price $3.50.

Beyond Yonder, by Oliver Justin Lee, Director of the Dearborn Observatory, Northwestern University. Cloth. 169 pages. 13×19 cm. 1939. Chapman and Grimes, Inc., 110 Mount Vernon Street, Boston, Mass. Price $2.50.

Life and Environment, by Paul B. Sears, Professor of Botany, Oberlin College. Cloth. Pages xx+175. 14×21.5 cm. 1939. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

An Introduction to Modern Geometry, by Levi S. Shively, Associate Professor of Mathematics, Ball State Teachers College. Muncie, Indiana. Cloth. Pages xi+167. 14×21.5 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.00.

Engineering Descriptive Geometry, by Charles Elmer Rowe, Professor of Drawing, University of Texas. Cloth. Pages vii+299. 15×23 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price 2.50.

The Arithmetic of Business, by Frank J. McMackin, Principal, William L. Dickinson High School, Jersey City; John A. Marsh, Head of Mathematics Department, High School of Commerce, Boston; and Charles E. Baten, Instructor in the Commercial Department, The Lewis and Clark High School, Spokane. Cloth. Pages ix+486. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.48.

New Practical Mathematics, by N. J. Lennes. Cloth. Pages ix+426. 13×20 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.32.

Astronomy, by William T. Skilling, Ret., San Diego State College, and Robert S. Richardson, Mount Wilson Observatory. Cloth. Pages xi+579. 13×21.5 cm. 1939. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $3.00.

Problems in Mechanics, by G. B. Karelitz, Professor of Mechanical Engineering, Columbia University; J. Ormondroyd, Professor of Engineering Mechanics, University of Michigan; and J. M. Garrelts, Associate Professor of Civil Engineering, Columbia University. Cloth. Pages ix+271. 14.5×23 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.50.

A Picture Dictionary for Children, by Garnette Watters, Director of the Language Department of the Public Schools, Hamtramch, Michigan, and S. A. Courtis, Professor of Education, University of Michigan. Cardboard. 478 pages. 21×28 cm. 1939. Grosset and Dunlap, Inc., 1107 Broadway at 24th Street, New York, N. Y. Price $1.00.

Fabre and Mathematics, by Lao Genevra Simons, Chairman, Department of Mathematics, Hunter College of the City of New York. Cloth. Pages v+101. 12.5×19 cm. 1939. Scripta Mathematica, Amsterdam Avenue and 186th Street, New York, N. Y. Price $1.00.

Biology of the Vertebrates, by Herbert Eugene Walter, Emeritus Professor of Biology, Brown University. Revised Edition. Cloth. Pages xxv+882. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

Mathematics of Statistics, Part One, by John F. Kenney, Northwestern University. Cloth. Pages x+248. 15×23 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.50.

Mathematics of Statistics, Part Two, by John F. Kenney, Northwestern

University. Cloth. Pages ix+202. 15×23 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.25.

Theoretical and Applied Electrochemistry, by Maurice de Kay Thompson, Professor of Electrochemistry in the Massachusetts Institute of Technology. Third Edition. Cloth. Pages xxi+535. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.00.

Introductory College Chemistry, by Harry N. Holmes, Professor of Chemistry in Oberlin College. Third Edition. Cloth. Pages viii+619. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

Plane Trigonometry, by W. T. Stratton, Professor and Head of Department of Mathematics, Kansas State College, and R. D. Daugherty, Assistant Professor of Mathematics, Kansas State College. Cloth. Pages 88+118. 15×23 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $2.25.

Engineering Drawing, by H. H. Winstanley, Lecturer in Mechanical Engineering, Wigan and District Mining and Technical College, Wigan, England. Cloth. Pages iv+128. 22×28 cm. 1939. Longmans, Green and Company, Inc., 114 Fifth Avenue, New York, N. Y. Price $1.60.

Perspective Made Easy, by Ernest R. Njorling. Cloth. Pages xii+203. 14×21 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.40.

Coordinate Geometry, by Luther Pfahler Eisenhart, Professor of Mathematics, Princeton University. Cloth. Pages xi+298. 14×21 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.50.

Business Arithmetic for College Students, by William S. Schlauch, School of Commerce, Accounts and Finance, New York University, N. Y. Cloth. Pages vii+299. 15×23 cm. 1939. F. S. Crofts and Company, 41 Union Square, West, New York, N. Y. Price $2.80.

German-English Science Dictionary for Students in the Agricultural, Biological and Physical Sciences, by Louis De Vries, Professor of Modern Languages, Iowa State College with the Collaboration of Members of the Graduate Faculty. Cloth. Pages x+473. 12.5×18 cm. 1939. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.00.

College Algebra, by Paul K. Rees, Assistant Professor of Mathematics, New Mexico State College of Agriculture and Mechanic Arts, and Fred W. Sparks, Professor of Mathematics, Texas Technological College. Cloth. Pages xi+312. 15×23 cm. 1939. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.25.

Mathematical Recreations and Essays, by W. W. Rouse Ball, Late Fellow of Trinity College, Cambridge, and revised by H. S. M. Coxeter, Past Fellow of Trinity College, Cambridge. Eleventh Edition. Cloth. Pages xvi+418. 13×20 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.75.

Differential and Integral Calculus, by John Haven Neelley, Professor of Mathematics in the Carnegie Institute of Technology, and Joshua Irving Tracey, Associate Professor of Mathematics in Yale University. Second Edition. Cloth. Pages ix+495. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.25.

The Living Thoughts of Darwin, presented by Julian Huxley, Assisted by James Fisher. Cloth. 156 pages. 11.5×18 cm. 1939. Longmans, Green and Company, 114 Fifth Avenue, New York, N. Y. Price $1.00.

The Demonstration Laboratory of Physics at the University of Chicago, by Harvey B. Lemon, Professor of Physics, The University of Chicago, and Fitz-Hugh Marshall, Assistant in Physics, The University of Chicago. Paper. 127 pages. 17×23.5 cm. 1939. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $1.50.

Physik für Studierende an Technischen Hochschulen und Universitäten, by Dr. Paul Wessel, Engineer, edited by Dr. V. Riederer. Cloth. 514+36 pages. 12×20.5 cm. 1939. Ernst Reinhardt, München, Germany. Price 4.90 Marks.

Visual Outline of General Biology, by Professor George Child, Amherst College. Paper. Pages iv+97. 13.5×21 cm. 1939. Longmans, Green and Company, 114 Fifth Avenue, New York, N. Y. Price 75 cents.

Practical Shop Mathematics, Volume I—Elementary, Volume II—Advanced, by John H. Wolfe, Supervisor of Apprentice School, Ford Motor Company, and Everett R. Phelps, Associate Professor of Physics, Wayne University. Revised Edition. Cloth. Volume I, pages xiv+349, Volume II, pages xiv+318. 12×20 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y.

The Storehouse of Civilization, by C. C. Furnas, Associate Professor of Chemical Engineering, Yale University. Cloth. Pages xx+562. 13.5×21.5 cm. 1939. Bureau of Publications, Teachers College, Columbia University, 525 West 120th Street, New York, N. Y.

Handbook of Chemistry and Physics, A Ready-Reference Book of Chemical and Physical Data, by Editor in Chief, Charles D. Hodgman, Associate Professor of Physics at Case School of Applied Science. Twenty-third Edition. Cloth. Pages xviii+2221. 11.5×18 cm. 1939. The Chemical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio. Price De Luxe Edition $6.00 in United States and Canada, Six Dollars and Fifty Cents elsewhere.

Fundamentals of Zoölogy, by Wm. J. Tinkle, Professor of Biology, Taylor University, Upland, Indiana. Cloth. 492 pages. 14×21.5 cm. 1939. Zondervan Publishing House, 815 Franklin Street, Grand Rapids, Mich. Price $3.00.

Discovery of the Elements, by Mary Elvira Weeks, Associate Professor of Chemistry at the University of Kansas. Cloth. Pages v+470. 15.5×23.5 cm. 1939. Journal of Chemical Education, 20th and Northampton Streets, Easton, Pa.

Field Book of Animals in Winter, by Ann Haven Morgan, Professor of Zoology, Mount Holyoke College. Cloth. Pages xv+527. 10×17 cm. 1939. G. P. Putnam's Sons, 2 West 45th Street, New York, N. Y. Price $3.50.

A Hundred Years of Astronomy, by Reginald L. Waterfield, Member of the Council of the Royal Astronomical Society. Cloth. 526 pages. 13×21.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.75.

Science Experiences with Home Equipment, by Carleton John Lynde, Professor of Physics in Teachers College, Columbia University, New York City. Cloth. Pages xiii+226. 12.5×20 cm. 1937. International Textbook Company, 1001 Wyoming Avenue, Scranton, Pa. Price $1.34.

Science Experiences with Inexpensive Equipment, by Carleton J. Lynde, Professor of Physics in Teachers College, Columbia University, New York City. Cloth. Pages xiii+258. 12.5×20 cm. 1939. International Textbook Company, 1001 Wyoming Avenue, Scranton, Pa. Price $1.60.

BOOK REVIEWS

The Nature of Crystals, by A. G. Ward, Scholar of Trinity College, Cambridge. Cloth. Pages vii+114. 12×18.5 cm. 1938. Blackie and Son, Limited, 50 Old Bailey, London. Price 3s. 6d. net.

The author says: "If this book succeeds in persuading a few to leave

their arm-chairs, take up a test tube to prepare a crystal or two, and then to try and see how the shape, hardness, colour, and all the other properties depend on the internal structure, it will have achieved its purpose." The book will surely reach this goal, and it will do more. It will tell scientists in other specialized fields and even laymen of ordinary intelligence and an interest in the "flowers of the mineral world" many things about the form and structure of crystals, and why they have the properties that give them value.

The author first describes the work of early crystallographers in classifying crystals according to form, and then shows how x-ray analysis gives striking confirmation of the classifications made. Four typical crystals are described in detail: common salt represents the ionic type; diamond, the homopolar crystal; copper, a metallic structure packed together by free electrons; and paraffin, consisting of long chain hydrocarbon molecules bound together. Other more complex crystals are described in less detail. All of the crystal properties are shown to be the result of the arrangement of molecules, atoms, and electrons composing the crystal.

At various places suggestions are given for carrying on "experiments." Some of these are real experiments, many are directions for model building, some are problems for thought analysis and involve no manual work. The book is reliable, up-to-date, and an example of simplicity.

G. W. W.

Astronomy, by William T. Skilling, Ret., San Diego State College, and Robert S. Richardson, Mount Wilson Observatory. Cloth. Pages xi + 579. 13 × 21.5 cm. 1939. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $3.00.

This text is the product of two authors who have been engaged in quite different fields, the one a teacher, the other a research astronomer. The book reflects the experiences of each but seems to show more strongly the influence of the latter. Very little attention is given to a study of the sky as it appears to the eye unaided by astronomical instruments. The emphasis is on the more recent discoveries made at the great observatories. It is analytical rather than descriptive. Because of this it will lead the student to a careful consideration of astronomical theories but may fail to train him to use his eyes for his own enjoyment of the heavens. Limited attention is given to celestial coordinates and the location of points on the celestial sphere. Very little is said about the constellations. Emphasis is placed on the sun as a typical star near enough to be studied in many ways. Astrophysics and the evidence obtained by use of the spectroscope and spectrograph make up much of the subject matter. A student who attempts to use this text without first having familiarized himself with the elements of spectroscopy will not be able to grasp the significance of all the evidence presented.

The text is reliable throughout and is written in clear simple style. It is well edited and proof read leaving very few mechanical errors. The word "size" is frequently used vaguely where "diameter," "volume," or "mass" would be more definite. The Fahrenheit temperature scale is sometimes used, sometimes the centrigrade scale; in one instance both are used in the same paragraph. Good diagrams and halftones illustrate the text. In many respects this book should be rated superior and merits consideration by teachers of elementary astronomy.

G. W. W.

A Hundred Years of Astronomy, by Reginald L. Waterfield, Member of the Council of the Royal Astronomical Society. Cloth. 526 pages. 13 ×

21.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.75.

A Hundred Years of Astronomy reviews the stupendous increment to astronomical knowledge added in the period 1837–1937. It does not merely give a record of the results of research but describes the apparatus used, explains the methods of research, and analyzes the theory developed. The book is meant for the layman and for the student of astronomy who needs a review of the progress of the century just past. A layman cannot appreciate the magnitude of the progress made in this period but it will help if he recalls that before 1837 no star distance had been measured, Neptune had not been discovered, no terrestrial measurement of the velocity of light had been made, the principles of spectrum analysis were unknown, and photography had not been invented. These facts show that the job of the author was a big one and a detailed and complete record cannot be expected, but the book will satisfy the general reader and give the astronomer much of the record he needs. A bibliography of about two hundred selected references is appended.

G. W. W.

The Microbe Man, by Elenor Doorly. Cloth. Pages xiii and 160. 15 × 20 cm. D. Appleton-Century Co., Inc. New York and London. 1939. 21 black and white narrative illustrations.

This is a well written short biography of the life and especially the work of the great Louis Pasteur. It is in narrative form for the young high school boy and girl. The great biologic principles which Pasteur crystallized should find an easy lodgement in the minds of youthful readers and lead to clearer understanding of the necessarily more detailed material in the high school biological literature. $1.50.

A. G. ZANDER

Conservation in the United States, by A. F. Gustafson, Professor of Soil Technology, H. Ries, Professor of Geology, C. H. Guise, formerly Professor of Forest Management, W. J. Hamilton Jr., Assistant Professor of Zoölogy, all of Cornell University, Ithaca, New York. Cloth. Pages xi and 445. 189 photographs, 41 maps, tables and charts. 17 × 24 cm. Comstock Publishing Co., Inc. Ithaca, New York. 1939. $3.00.

This authoratative treatise on conservation comes at an opportune time. It presents a constructive program for the restoration of restorable natural resources and conservation of both the exhaustible and renewable types of natural resources. It could serve as an excellent sourcebook as well as a textbook on conservation for students as well as for the general public. The admitted objective of the book is its hope that it might develop the conservation viewpoint in the individual citizen as a part of his philosophy of living.

The book is divided into 4 general parts. Part I deals with the Conservation of Soil and Water Resources. Part II—Deals with Conservation of Forests, Parks and Grazing Lands. Part III—With the Conservation of Wild Life. Part IV—Conservation of Mineral Resources. The introduction gives a history of the conservation movement and the men active in it. There are 17 topical chapters, with a list of stimulating questions at the end of each chapter and at the end of the book a good supplementary reading list. The index is quite complete. The reviewer ventures the remark that in this book is brought together the latest and best on this very wide and prominent subject of conservation.

A. G. ZANDER

Plants Useful to Man, by Wilfred W. Robbins, University of California, and Francis Ramaley, University of Colorado. Second Edition. Cloth. Pages ix+422. 14×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.50.

The general plan of this book, first published in 1933, remains unchanged in this second edition. The chief emphasis is on the history, crop ecology and products of plants that are of economical importance to the United States. New material has been added and changes made in the sections dealing with alfalfa, flax, figs, potato and ornamental plants. Several of the simple line drawings have been replaced by new drawings or halftones.

The two introductory chapters deal with the following topics: proofs of early plant cultivation, ancient centers of agriculture, improvement of cereal grains, objectives of plant breeding, and the way plants are classified and named. The third chapter introduces the central theme of the text by describing the past and present relationship of thallophytes, bryophytes, pteridophytes and gymnosperms to the welfare of man. Angiosperms receive the major emphasis since they comprise a large percentage of the outstanding crop plants. Economically important crop plants of the field, garden, and orchard of the United States, ornamentals, and plants of the tropics that furnish imported materials for our use are grouped for discussion according to their respective families and genera. Historical, ecological, physiological and economic aspects are included along with the many uses man has made of the plants. There is a very worth-while chapter on medicinal plants that traces the relation of botanical and pharamaceutical knowledge. Five plants of outstanding medicinal value are described with special attention given to the history and physiological action of the crude drugs that they produce. The last chapter deals with industrial products that are difficult to place in definite categories of plant morphology. It includes the history, uses and economic importance of the following products: wood, coal, cork, fibers, straws and twigs, resins and turpentine, gums, vegetable dyes, fixed and volatile oils and rubber.

The relationship of plant physiology and morphology to economics is brought out by describing specific effects of structural and physiological characteristics of the plants on their respective products. The value of scientific names is clearly demonstrated for high school pupils in the clear and readable context. This book provides an excellent source of information for high school as well as college students and teachers of botany, agriculture, geography and economics.

LYLE F. STEWART

Chemical Tables from Handbook of Chemistry and Physics, by Charles D. Hodgman, M.S., Editor-in-chief. Flexible imitation leather. Pages xiv+1383. 11.5×18 cm. 1938. Chemical Rubber Publishing Co., 1900 West 112th Street, Cleveland, Ohio.

This volume includes all the material of the Handbook of Chemistry and Physics which is of particular interest to chemists. Only the table of logarithms has been included from the mathematical section. The page size is a little larger than that of the handbook. New tables included are Melting Point Index of Organic Compounds, Boiling Point Index of Organic Compounds, Potentials of Electrochemical Equivalents of the Elements, Ionization Potentials.

Complete or very extensive revisions have been made in the following: Isotopes, Calibration Tables for Thermocouples, Definitions of Chemical Terms, Plate and Film Speeds.

DRULEY PARKER

General and Inorganic Chemistry, by Frederick C. Irwin, B.S., Professor of Chemistry, Wayne University and G. Ray Sherwood, Ph.D., Assistant Professor of Chemistry, Wayne University. Cloth. Pages x+582. 14×21.5 cm. 1939. P. Blakiston's Son & Co., Inc. Philadelphia. Price $3.50.

The authors state in the preface that "an attempt has been made to keep two themes in mind: (1) to acquaint the student with the contributions that the science of chemistry can make toward an understanding of his own physical world and (2) to prepare him for the next course in chemistry, if he continues with the subject." An examination of the text indicates that the authors have made a conscious effort to follow their themes.

The first two chapters deal with physical principles such as the gas laws and kinetic theory. Evidently the authors sense the same lack of adequate preparation in physical principles that bothers so many students.

Chapters on organic chemistry are placed relatively early in the book which would probably be desirable for those students whose major interest is in some other field.

Some of the diagrams, drawings and halftones are not of a quality which is in harmony with the other parts of the text. Teachers of the first course in chemistry will want to examine this text.

DRULEY PARKER

Exploring the World of Science, by Charles H. Lake, Supt. of Public Schools and Formerly Principal of East Technical High School, Cleveland, Henry P. Harley, Supervising Teacher of Science, Fairmount Junior High Training School, Cleveland, and Louis E. Welton, Assistant Principal and Formerly Head of Science Department, John Hay High School, Cleveland. Cloth. Pages x+710. 21×15 cm. 384 Figures. 1934. Revised 1939. Silver Burdett and Company, New York, N. Y. Price $1.80.

This is a comprehensive textbook on general science, evidently intended for students with a considerable science background. It is clearly and simply written and is extensively illustrated, with actual photographs as well as line drawings.

Each unit begins with a short interest-generating introduction, which is followed by the several chapters or subdivisions of the unit. The chapter headings are stated in the form of questions, and are followed by thought stimulating facts stated in question form. Each chapter is supplied with many laboratory experiments, demonstrations, and exercises; and the student is encouraged to find the answers to his questions from his own experiences. Each unit is provided with a number of thought questions, suggested projects and reports, and references for more intensive study.

The book covers a wide area of the scientific environment of the pupil, under the following unit headings: I. What Is the Atmosphere and How Does It Affect Our Daily Lives? II. What Is Sound and What Use Does Man Make of It? III. What Is Water and What Use Does Man Make of It? IV. How Do Weather and Climate Affect Our Lives? V. What Is the Universe and What Is the Place of the Earth in It? VI. What Is Soil and How Is It Formed? VII. What Simple Building Material Makes Up the Universe? VIII. What Are the Forces of Nature and What Use Does Man Make of Them? IX. How Have Machines Made the Work of Man Easier? X. How Does Man Secure Heat for His Daily Needs? XI. What Is Light and How Does Man Make Use of It? XII. How Has Electricity Become Man's Greatest Servant? XIII. How Do Plants Make Food and Store Up

Energy? XIV. Of What Use Are Animals to Man? XV. How Is It Possible To Build a Healthy Body? XVI. How Can You Keep Your Body Healthy?

The book is also noteworthy in that the first chapter titled, How Has Science Remade the World?, gives an excellent summary of the development of science, an explanation of the "Scientific Method," and a discussion of the contribution of science to our changing environment.

W. A. PORTER

Bacteriology, by Estelle D. Buchanan, Formerly Assistant Professor of Botany, Iowa State College, and Robert Earle Buchanan, Professor of Bacteriology, Iowa State College and Bacteriologist of the Iowa Agricultural Experiment Station. Fourth Edition. Cloth. Pages xv+548. 13.5×21 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

In this book the authors state that an attempt has been made to keep in mind the needs and interests of liberal arts and science students, even though the emphasis throughout has been on the non-medical but technical phases of the subject.

"New points of view and more extensive information as to the organisms themselves, as well as the changes they bring about, have made necessary several new chapters and an almost complete rewriting of others."

The book consists of 54 chapters, grouped under the following five sections:

I. Morphology, classification, and distribution of microorganisms.
II. Cultivation and observation of microorganisms.
III. Physiology of microorganisms.
IV. Effects of organisms on their environment, including fermentations.
V. Microorganisms and health.

The Protozoa are dealt with very briefly in a chapter on Pathogenic Protozoa.

The figures are unusually good, partly as a result of the use of an excellent grade of glazed paper in the book.

There are three valuable appendices:

A. Keys to orders, families, and genera of bacteria.
B. Keys to the families and genera of yeasts.
C. Key to orders, families, and genera of common molds (illustrated by a large number of drawings).

There are separate author and subject indexes. The material chosen is interesting and its presentation is clear and readable. The student who is interested in the basic problems of microorganisms, particularly as they relate to the plant kingdom, can not fail to find pleasure in the reading of this attractive book.

EDWARD C. COLIN, *Chicago Teachers College*

Biology, by Thurman J. Moon, Head of the Science Department, The High school, Middletown, New York, and Paul B. Mann, First Assistant in Biologic Science and Head of Department of Biology, Evander Childs High School, New York City. Cloth. Pages x+866+c. 13×20.5 cm. 1938. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $2.00.

This book is a revision of *Biology for Beginners*, 1933. Much new material has been added. The sixty chapters are grouped under ten units.

Except for one serious fault, the book would, in the opinion of the reviewer, be entitled to a grade of "A" as a textbook for high school students. On many of the drawings, especially the more complex ones, the old method of labeling (using letters opposite the structures with a legend

in fine type printed below) is used, instead of the newer method of placing the label in full at the end of the guide line. As a time-saver and sight-saver the latter method is so far superior to the other that there can be no excuse for not using it—especially in a book for beginners. The contrast in the two methods is noticeable in this book, since a number of the drawings are labeled in the modern manner.

The text is exceptionally interesting, well written, and up-to-date. There are numerous references to recent investigations. Lists of questions, reading references, practical suggestions, and "recognition terms" at the ends of the chapters add greatly to the usefulness of the book as a textbook. These helps should be of special value to the inexperienced teacher.

EDWARD C. COLIN, *Chicago Teachers College*

Higher Mathematics with Applications to Science and Engineering, by Richard Stevens Burington, Assistant Professor of Mathematics, The Case School of Applied Science and Charles Chapman Torrance, Instructor in Mathematics, The Case School of Applied Science. Cloth. Pages xiii+844. 14.5×22.5 cm. 1939. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $5.00.

According to the preface, this book is designed primarily to meet the growing needs of students interested in the applications of mathematics to physics and engineering. Although many references and problems cover applications, there is a large amount of material such as would be found in many texts in pure mathematics.

The first two chapters, covering over three hundred pages, are devoted to differential and integral calculus. Although many of the concepts customarily studied in a first course in calculus are reviewed, emphasis is placed upon rigor, upon the meaning of the concepts studied, and upon the conditions under which results are valid. A liberal use of functions which are not defined by simple algebraic expressions and many of which he has never encountered before should make the student realize the necessity for rigorous definitions and statements of theorems. The scope of the material is perhaps indicated by the mere statement that among other topics covered are hyperbolic functions; the Riemann Theory of integration; Green's Theorem; Gamma and Beta functions; differentiation and integration of definite integrals.

Obviously much more material is presented than would be taught in any one course. The material on differential equations includes systems of differential equations; numerical solutions; Legendre's and Bessel's equations; partial differential equations, including Laplace's equation in three variables. The text devotes considerable space to functions of a complex variable. Other topics include a chapter on algebra and vector analysis, including some differential geometry and tensor analysis; calculus of variations; dynamics; and an introduction to real variable theory.

The typography is excellent, and the illustrations well drawn. For those who wish to pursue certain subjects further, a selected bibliography is given.

Probably due to typographical error, the proof of the transcendance of π is credited to Ludermann, rather than Lindemann. In a few places one might wish that the student were furnished with a little more information regarding the conditions implied; for example on page 162 it might be noted that the condition stated is sufficient but not necessary for the function to have a relative maximum; again on page 177 formulas (5) do not make it clear whether or not any conditions must be imposed on the value of u.

CECIL B. READ, *University of Wichita*

Algebra and Its Uses, Book One, by Nathan Silberstein, Chairman of the Mathematics Department, James Monroe High School, New York City, Marquis J. Newell, Mathematics Department, Evanston Township High School, Evanston, Illinois, and George A. Harper, Headmaster, Southern Arizona School for Boys, Tucson, Arizona. Cloth. Pages viii+432. 21×14.5 cm. 1938. Row, Peterson and Company, Evanston, Illinois. Price $1.24.

The pupil is introduced to the use of algebra symbols after a discussion of non-mathematical symbols with which he is at least casually familiar. The function concept is then presented by means of graphs, tables and formulas. There is frequent tie-up of the algebra with the arithmetic ideas with which the pupil is already familiar. There is an abundance of exercises and problems so that the course can be fitted to the needs of pupils of varying abilities. There are frequent reviews and tests. A feature of the book is the presentation of a group of practice problems to be done at the time of the giving of the assignment. Following the chapter on quadratic equations, there is a chapter on geometry and trigonometry to be used if the teacher desires and if time permits. Biographical notes and illustrations add to the interest of the book.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Algebra and Its Uses, Book Two, by Nathan Silberstein, Chairman of The Mathematics Department, James Monroe High School, New York City, Marquis J. Newell, Mathematics Department, Evanston Township High School, Evanston, Illinois, and George A. Harper, Headmaster, Southern Arizona School for Boys, Tucson, Arizona. Cloth. Pages xvi+423. 21×14.5 cm. 1938. Row, Peterson and Company, Evanston, Illinois. Price $1.24.

The book opens with an extensive review of the first course in algebra and introduces in connection with this review many extensions to more complicated exercises and problems. The function notation is introduced as an extension of the pupil's previously acquired familiarity with the function concept. The Factor and Remainder Theorems are presented and considerable practice is given in their use. Numerical trigonometry is introduced as an integral part of the course. Logarithms, simultaneous quadratics, progressions and the Binomial Theorem are treated in some detail. Illustrated biographical notes add interest to the book. There are reviews and tests and an abundance of exercise and problem material.

WALTER H. CARNAHAN

Analytic Geometry, by Clyde E. Love, Professor of Mathematics in the University of Michigan. Third Edition. Cloth. Pages xiv+279. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.75.

The third edition of this successful text retains the good features of the former editions. In addition the subject matter has been reorganized so as to treat the conic sections more effectively than in previous editions and at the same time require much less space. Three new chapters have been added covering algebraic curves, special curves of historical interest, and curve fitting. The introduction to Solid Analytic Geometry is one of the best to be found in any elementary text. The exposition throughout is brief and to the point—a characteristic of all of Love's texts.

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